the Petroleum Engineer

MARCH • 1948

VOLUME XIX NUMBER 6

...ds for Operating Men

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TO ALL

NATURAL GASOLINE MEN

Greetings

from the

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THE PRICE FACTOR

"It is price that controls the volume of production, and also the volume of demand," so stated Walter G. Dunlop, president of Sun Oil Company. Excerpts from his remarkably straightforward statement, made before the House Interstate and Foreign Commerce Committee, have very pertinent reference to the price factor:

"When prices are subject to control, or administration, by the government, or for that matter by any influence except that of the market place, the functioning of a competitive enterprise economy is thrown out of kilter—shortages or surpluses develop, productive facilities become over-expanded, or, as the case may be, are left undeveloped. When a price for one commodity is artificially repressed, while prices for competitive commodities are permitted to rise, consumer demand shifts. This has happened in the case of oil.

"The oil industry today is faced with a tight supply-demand situation which had its origin, in good part, in the freezing of crude oil prices at a depressed level for four years. The result was a sharp drop in well drilling.

"The price increases that have taken place since the end of the war, therefore, have been in the nature of corrective actions required by the actual supply-demand situation.

"Generally, the relationship of the prices of petroleum products to the prices of other finished commodities have paralleled the crude oil pattern.

"Prior to the most recent crude oil advances, with their influences on petroleum products, these prices certainly were not so high as to have an effect on demand, especially for heating oil. In every category of products, 1947 demand was sharply above 1946—the previous record year.

"Without doubt oil prices which in 1946 and most of 1947 lagged behind *the general price pattern played an important part in creating this sharp increase in demand.* (The italics are ours). Obviously, the oil industry cannot keep up with such an accelerated demand for furnace oils over a period of several years without severe strain and disruption.

"Consequently, the practicalities of the situation require price increases, not only to stimulate more production but also — and just as important — to check the expansion of a demand for fuel oils that has been growing out of all bounds.

"The obvious fact, as has been frequently stated, is that oil cannot heat all the homes in the country, nor can oil continue, as it has in recent years, to supply virtually all the increase in the nation's energy load. This is a matter, I believe, of great fundamental importance to the nation.

"If petroleum and natural gas are to continue to contribute their proportionate share to increase potential energy—which is the basis of our standard of living—then petroleum and natural gas facilities will have to be greatly expanded in the years immediately ahead.

"This will require large new capital investment to explore for new sources of crude oil and natural gas, to produce them, refine and process them, transport them by tanker and pipeline and to distribute the resulting products to consumers. It will require many billions of dollars.

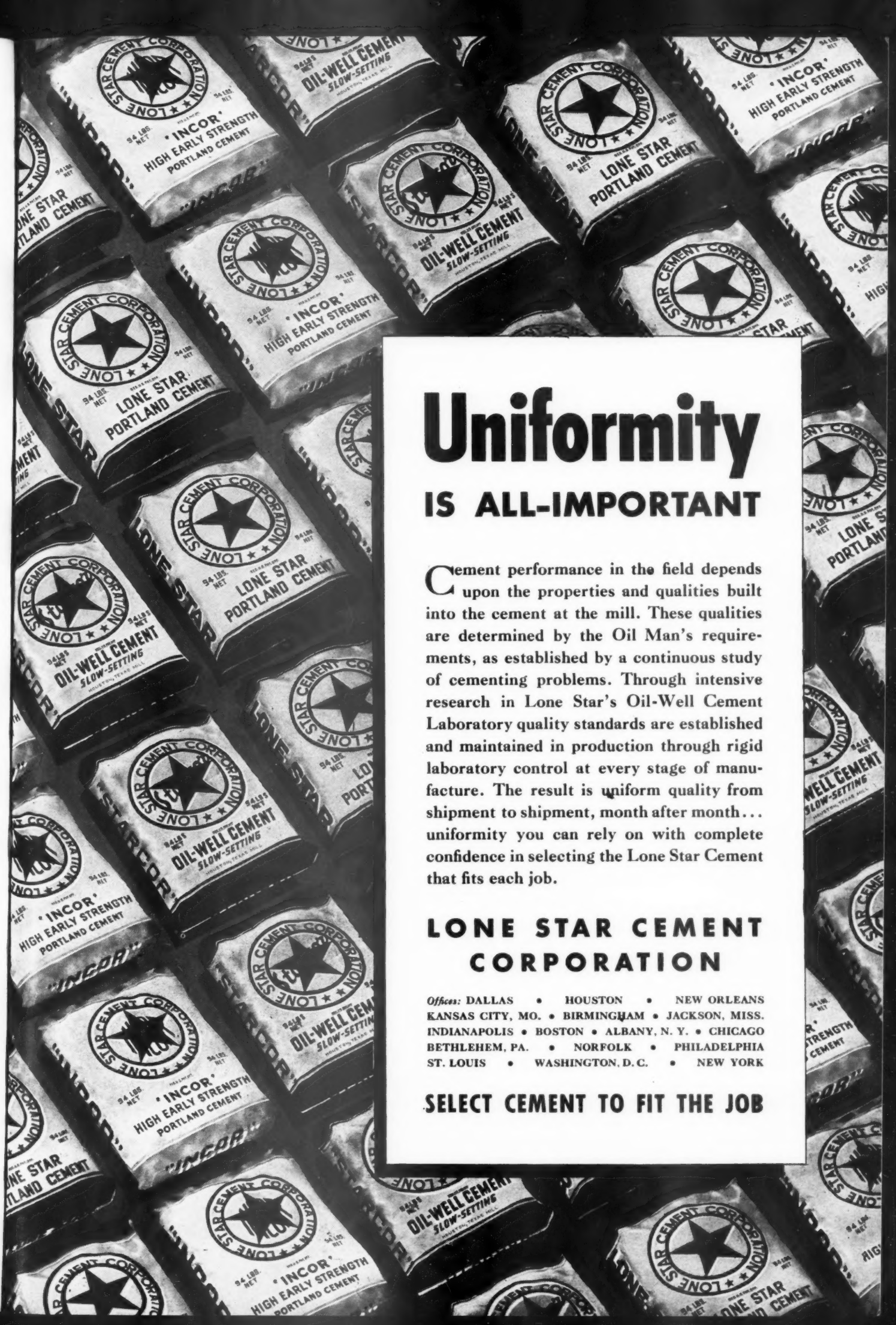
"Traditionally the petroleum industry has obtained approximately seven-eighths of its capital investment from its earnings. Drastically high taxes on individual incomes are absorbing funds that normally would go into the capital market, while restrictions on bank credit are narrowing that source for investment money.

"So it appears that the only source of money for this expansion is current earnings and these earnings depend upon adequate prices for petroleum and its products. Thus current prices serve the public welfare, for upon them depend adequate supplies in the future.

"Required also is steel for the additional pipelines needed. Again, price becomes a strong factor in creating incentives necessary to stimulate such operations. No other instrumentality but price can get the job done.

"Competition within the petroleum industry for many years has been spirited and sharp. The efforts which have been and now are being made to provide adequate supplies of petroleum products for the nation indicate that the spirit of competition remains alive and strong. It is more than sufficient, by and large, to assure fair treatment to American consumers."

Coming as it does from the head of one of the most aggressive integrated oil companies in the country, the statement, from which the foregoing excerpts were taken, is refreshing for its forthrightness. It points up the underlying cause of many of the recent difficulties that have arisen in the oil industry. It is a valiant defense of the effectiveness of price in bringing supply and demand into line when private enterprise is allowed to function on a free, fair, and competitive basis.—K. C. S.



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SELECT CEMENT TO FIT THE JOB

SCANNING WASHINGTON'S OIL HORIZON

By MILBURN PETTY

WASHINGTON—Foreign aspects of a national oil policy are discussed in a report—nearly two years in the making—now being studied by President Truman's top advisers on foreign affairs.

This report was prepared by the State Department's interdepartment technical petroleum committee for the Executive Committee on Economic Foreign Policy, which was set up in 1944 by the late President Roosevelt as the top presidential advisory agency on such matters.

Until recently, the development of this report has been shrouded in secrecy. But congressional oil committees became interested. So, a good idea of what the report is about is now available.

It is unlikely that this report will be adopted in its entirety as a basis of foreign oil policy. There are some points in it that the industry won't like, others that Congress won't go for, and still others that some foreign governments may question. But, all in all, it is interesting as a consensus of oil thinking among the government agencies. It can be considered as the starting point for discussions of a national oil policy.

The report starts off with the assumption that the United States is likely to become increasingly dependent on foreign oil, then discusses the objectives of a foreign policy and methods of promoting American interests in oil reserves and operations abroad.

No. 1 objective of U. S. oil policy, according to this report, should be the development of Middle East fields to the point where they can supply the Eastern Hemisphere as well as part of the requirements of the Western Hemisphere so that a reserve productive capacity can be built up in this hemisphere for emergencies.

Next, intergovernment relations should be such that oil resources in the Western Hemisphere can be adequately developed and made available for hemispheric defense.

Established American rights in foreign oil reserves should be preserved. Foreign operations of American companies should be expanded to the maximum, the report said.

First among its recommendations for attaining these objectives, the report lists action by the U. S. government to open the door for entry or expansion of American oil operations in foreign countries where such action is necessary.

General legislation setting forth rights and liabilities of operating oil companies is preferable to negotiated concessions, according to this State Department committee report. The government should encourage the enactment of uniform oil legislation by foreign countries.

Bilateral discussions with Latin American countries on oil should be initiated immediately, the report said. Anglo-American oil talks should be continued.

On government-industry relations, the committee recommended that more American oil companies be encouraged to enter the foreign field and that diplomatic support be strengthened where possible.

Greater attention, however, should be given to the development of oil company policies likely to avoid friction with foreign governments, the committee said. The report went so far as to suggest that the U. S. government should assume a positive responsibility for consulting with and advising American companies on all aspects of company policy that might endanger their continued operations in foreign countries.

Also, the government should scrutinize all negotiated concessions that any American company proposes to enter, advising against seeking too much in the way of privileges and immunities or extent of territory. And, if any existing concessions are "excessive" in this regard, the companies should be urged to modify them voluntarily. American companies should be warned that the U. S. government frowns on cartels in any shape or form.

The committee also recommended that, except for possibly the limited financing of construction of facilities under emergency conditions, the government should not engage in oil industry operations abroad.

As to export-import policy, the report recommended against imposing any quotas on oil imports entering the U. S. or increasing the so-called oil tariff. No export controls should be imposed except in case of emergencies.

In discussing these objectives and recommendations, the committee gave hints as to its attitude on controversial issues.

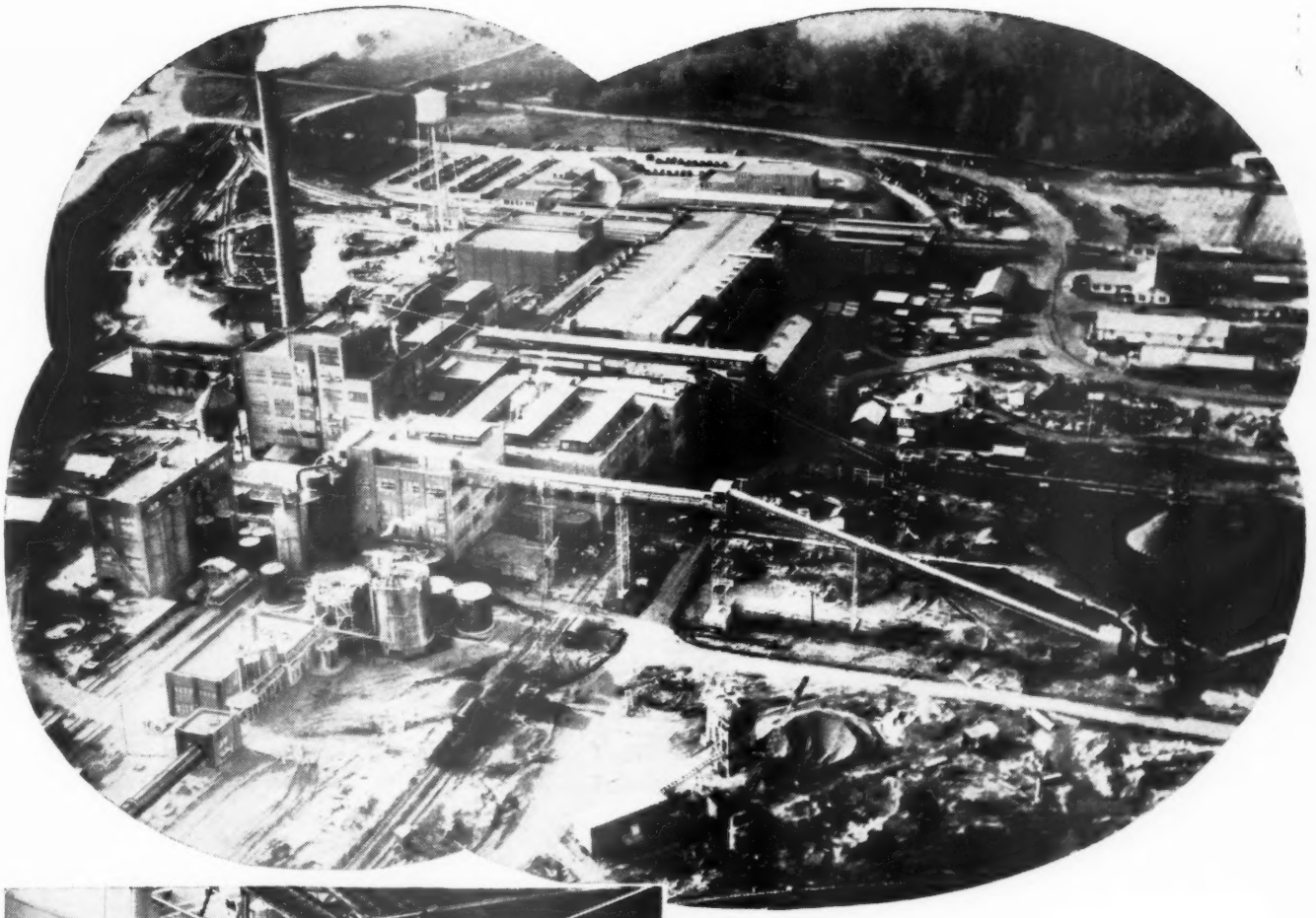
The report recognized that it was not feasible at this time (because of violent opposition by the American oil industry) to suggest an international tribunal for arbitrating oil disputes. But it did suggest that periodic discussions be held with Latin American oil countries. Also, the committee endorsed provisions in the Anglo-American Oil Agreement for multilateral cooperation. There was also a cautious suggestion for the creation of international machinery to study common problems in international oil trade with a view to possibly setting up a more formal organization.

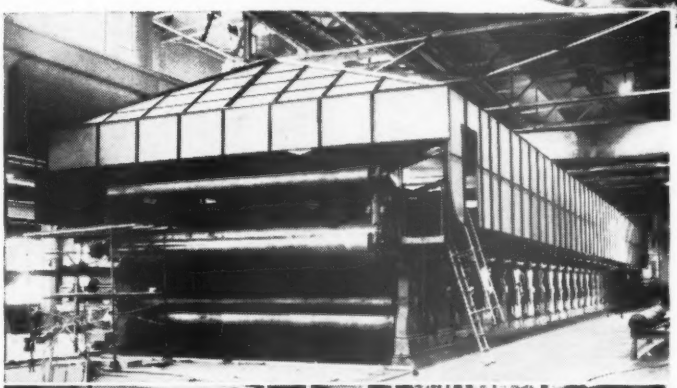
Broader participation in American foreign oil operations, particularly by medium-sized companies, would tend to lessen any suspicion that might arise from the fact that only a few large companies are engaged in foreign oil operations, according to the committee, which urged that the time has come for the government to encourage more companies to go abroad.

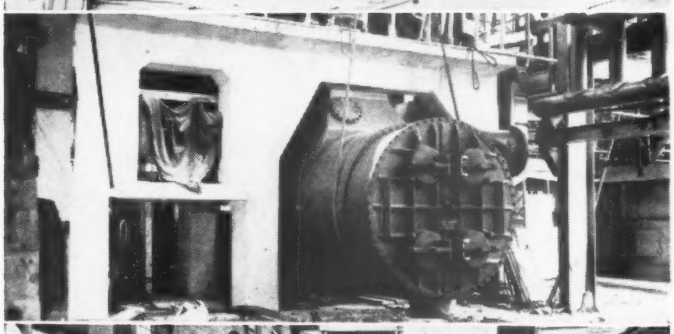
The State Department committee took note of demands by American independent producers for a clear statement of "import policy" but, apparently, believes that the domestic producer has nothing to fear from imports now.

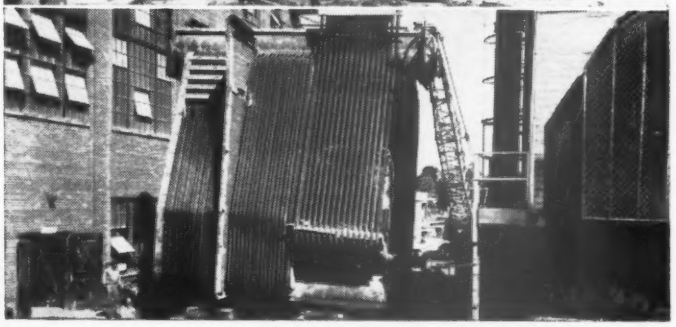
Conversely, the committee believes that there is no need of "forcing" imports now (which independent producers have accused the State Department of trying to do). Given adequate development opportunities and activities in the Western Hemisphere, the necessary flow of imports to fill the gap between domestic output and demand will take place naturally. The committee was also opposed to the government stockpiling foreign oil. Although favoring government encouragement of American companies developing oil in accessible foreign areas, thus increasing availability for imports, the committee was against government fostering of imports.

So long as there is a sustained foreign demand for most of the oil produced outside the U. S. and so long as the bulk of foreign oil is produced and controlled by a relatively few large oil companies, the committee does not believe that the lower production costs abroad will depress oil prices in the U. S. As both of these conditions are expected to prevail for some time, the committee feels that U. S. oil prices are unlikely to decline (barring a general depression) and, indeed, may go higher and make synthetic oil competitive with natural petroleum. So, no case can be made out either way for a change in the oil import duty, the committee felt. On the other hand, the report went on, higher prices to stimulate domestic exploration would be neither necessary nor appropriate.









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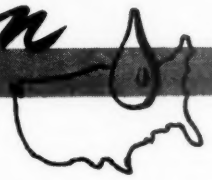
national petroleum situation



By H. J. STRUTH*,
Petroleum Economist

ADEQUATE GASOLINE. Predictions of a gasoline shortage this summer are likely to prove unfounded. Expansion of refining facilities, backed by a steady increase in crude production, has effected an abnormal pre-seasonal stock build-up. Still runs are 16 per cent above last year, gasoline output is 12 per cent greater and stocks are 6 per cent higher. When distillate fuel demand tapers off, yield of gasoline will be increased, supply will be considerably greater in response to expected increase in demand. Projected supply and demand figures scout the idea of a gasoline shortage this year.

*Editor, *The Petroleum Data Book.*

FAVORABLE SUPPLY OUTLOOK. Thanks to the system of free enterprise under which the oil industry operates, efforts to provide adequate supplies of petroleum products are meeting with success. In response to an increase in demand since January 1 of 8 per cent, the industry has increased supply 15 per cent. Demand for oils in the first 2 months of this year was 400,000 bbl daily above last year, but supply was boosted 702,000 bbl daily above last year. The results are shown by the fact that stock withdrawals this year have amounted to only 6,860,000 bbl, compared with the stock draft last year of 24,537,000 bbl. More crude production, greater refinery runs to stills and more imports this year present a materially improved supply outlook.

LESS DRILLING. Well completions in February were sharply lower than January, not because it was a shorter month but due to extremely severe winter weather. Daily average completions in February were 77, against 90 in January. Wildcat completions averaged 13 in February, against 16 in January. While equipment is still not in plentiful supply, it is likely that the advent of spring will bring a substantial gain in all drilling. Results since January 1 indicate a gain over the same period of last year of 12 per cent in all wells drilled and a gain of 17 per cent in wildcats. New operations at the close of February were 15 per cent above last year.

PEAK CRUDE PRODUCTION. A new peak in U. S. crude production of 5,389,000 bbl daily was recorded in February. This represents an increase over a year ago of 12 per cent. Production since January 1 averaged 5,378,000 bbl daily.

Comparative Statistics, February, 1948

*All figures are computed on a Bureau of Mines' Basis**

	Feb. 1948℗	Jan. 1948℗	Feb. 1947	This year to date	Last year to date	Per cent change
Wells drilling	4,400	¶4,450	3,810	4,400	3,810	+15
Total wells drilled	2,393	3,027	2,131	5,420	4,784	+13
Development wells	1,864	2,305	1,672	4,169	3,764	+11
Oil	1,329	1,640	1,098	2,969	2,473	+20
Gas	162	207	246	369	530	−31
Dry	373	458	328	831	761	+ 9
Per cent dry	20.0	19.9	19.6	19.9	20.2	− 0.3
Service wells	144	218	110	362	260	+39
Wildcat wells	385	504	349	889	760	+17
Oil	62	60	47	122	102	+20
Gas	18	19	14	37	24	+54
Dry	305	425	288	730	634	+15
Per cent dry	79.2	84.3	82.5	82.1	83.4	− .3
Crude supply*	164,400	¶175,700	143,137	340,100	295,700	+15
Daily average	5,669	5,668	5,112	5,668	5,012	
Crude demand‡	164,520	¶176,640	141,658	341,160	294,965	+16
Daily average	5,673	5,698	5,059	5,686	4,999	
Crude stocks	228,020	228,140	230,911	228,020	230,911	− 1
Days supply	40	40	47	40	47	
Natural gasoline production	11,500	12,100	9,864	23,600	20,435	+15
Daily average	397	390	352	393	346	
Motor fuel production	67,550	74,430	60,485	141,980	126,389	+12
Daily average	2,329	2,401	2,160	2,366	2,142	
Gasoline yield, per cent	38.2	39.2	39.7	38.7	39.8	− 1.1
Motor fuel demand‡	59,940	¶64,000	55,584	123,940	115,909	+ 7
Daily average	2,067	2,065	1,985	2,066	1,965	
Motor fuel stocks△	105,660	¶97,950	99,995	105,660	99,995	+ 6
Days supply	51	47	50	51	50	•
Fuel oil production	70,810	74,650	56,136	145,460	116,657	+25
Daily average	2,442	2,408	2,005	2,424	1,977	
Fuel oil demand‡	86,630	¶92,530	78,002	179,160	163,569	+10
Daily average	2,987	2,985	2,786	2,986	2,772	
Fuel oil stocks	79,850	87,940	75,381	79,850	75,381	+ 6
Days supply	27	29	27	27	27	
Refinery still runs	157,200	168,480	134,953	325,680	281,850	+16
Daily average	5,421	5,435	4,820	5,428	4,777	
All refined stocks	266,500	269,300	251,646	266,500	251,646	+ 6
Days supply	43	43	42	43	42	

Supply and Demand—All Oils

	Feb. 1948℗	Jan. 1948℗	Feb. 1947	This year to date	Last year to date	Per cent change
Total supply, all oils	181,950	¶193,800	158,678	375,750	328,099	+15
Daily average	6,274	6,252	5,667	6,263	5,561	
Total demand‡, all oils	184,870	¶197,740	169,257	382,610	352,636	+ 8
Daily average	6,375	6,379	6,045	6,377	5,977	
Change in stocks (total)	− 2,920	− 3,940	−10,579	− 6,860	−24,537	

Current Crude Oil Prices

U. S. average	$2.61	Louisiana	$2.62
Texas	2.61	Arkansas	2.43
California	2.42	New Mexico	2.40
Oklahoma	2.63	Mississippi	2.42
Kansas	2.62	Illinois	2.76
		Other states	3.15

Basic crude prices:

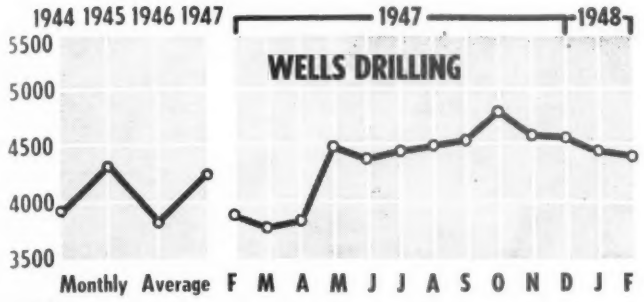
Oklahoma-Kansas (36 gr.)	$2.5
Texas Gulf Coast (36 gr.)	2.8
East Texas	2.6
West Texas (36 gr.)	2.4
California Signal Hill (26 gr.)	2.44
Pennsylvania, Bradford	5.00

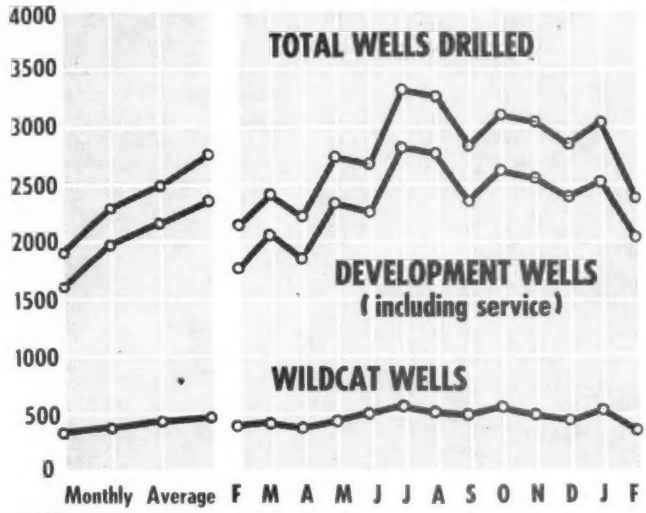
Drilling and Production Statistics by States

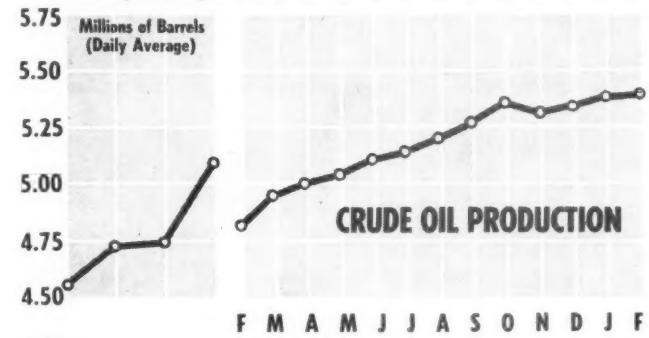
	Feb. 1948℗	Jan. 1948℗	Feb. 1947	This year to date	Last year to date	Per cent change
Wells drilled (excl service)	2,249	2,809	2,021	5,058	4,524	+ 12
Arkansas	28	35	14	63	37	+ 70
California	213	216	155	429	325	+ 32
Illinois	154	173	126	327	292	+ 12
Kansas	197	244	187	441	398	+ 11
Louisiana	123	144	94	267	196	+ 36
Mississippi	32	35	22	67	57	+ 18
New Mexico	32	60	39	92	81	+ 14
Oklahoma	260	334	311	594	660	− 10
Texas	715	892	618	1,607	1,383	+ 16
Other states	495	676	455	1,171	1,095	+ 7
Wildcats drilled (incl above)	385	504	349	889	760	+ 17
Arkansas	7	11	3	18	8	+125
California	25	26	25	51	50	+ 2
Illinois	33	28	20	61	60	+ 2
Kansas	30	35	25	65	54	+ 20
Louisiana	20	16	14	36	34	+ 6
Mississippi	6	9	9	15	20	− 25
New Mexico	3	3	5	6	10	− 40
Oklahoma	52	84	91	136	163	− 17
Texas	149	222	120	371	256	+ 45
Other states	60	70	37	130	105	+ 24
Daily crude production	5,389	5,368	4,810	5,378	4,737	+ 14
Arkansas	87	87	80	87	80	+ 9
California	930	935	901	933	892	+ 5
Illinois	175	171	189	173	191	− 9
Kansas	281	292	272	287	270	+ 6
Louisiana	477	475	420	476	417	+ 14
Mississippi	114	115	84	115	86	+ 34
New Mexico	128	125	106	126	104	+ 21
Oklahoma	409	406	371	408	367	+ 11
Texas	2,428	2,401	2,071	2,414	2,012	+ 20
Wyoming	135	134	112	134	109	+ 23
Other states	225	227	204	225	209	+ 8

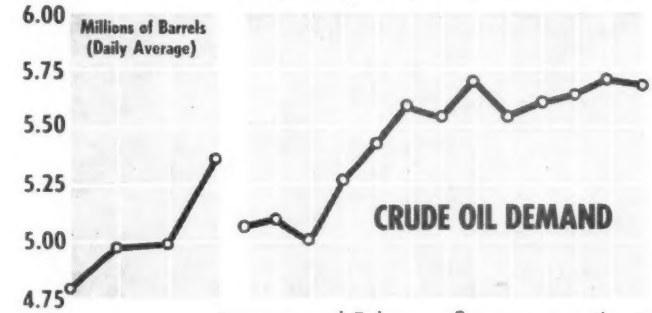
*Unless otherwise stated all figures represent thousands of barrels. ℗–Preliminary. •Includes domestic production and imports.
‡Total demand, including exports. △Includes finished and natural gasoline. ¶Revised.

Preliminary estimates based upon data supplied by American Petroleum Institute, U. S. Bureau of Mines, State Agencies, and other official sources.

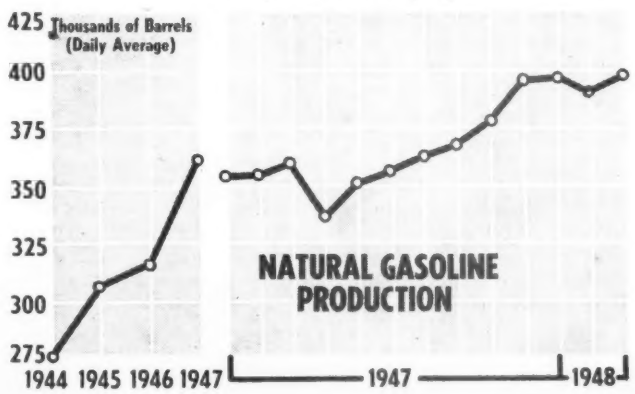


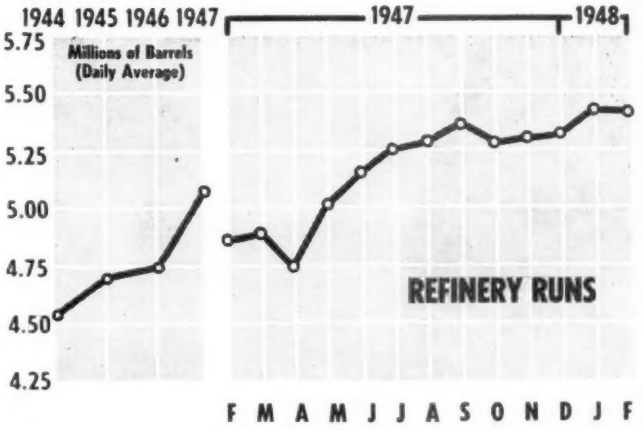


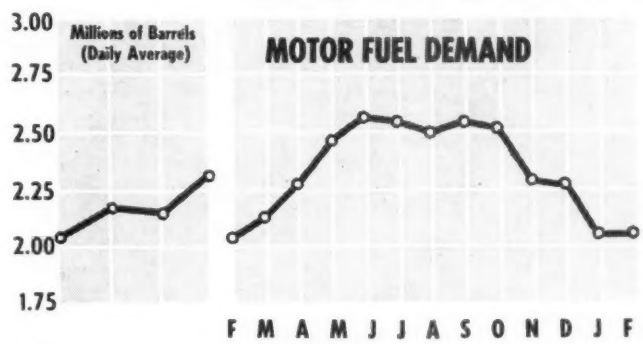


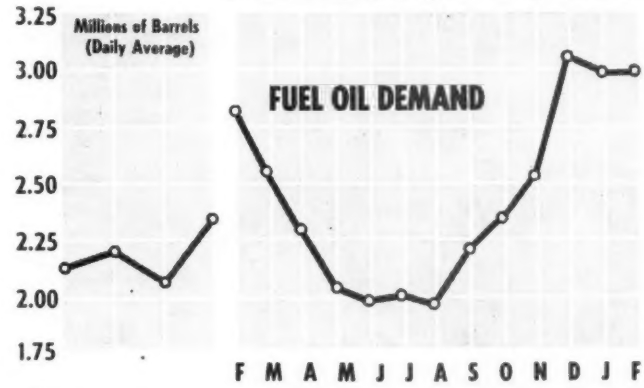


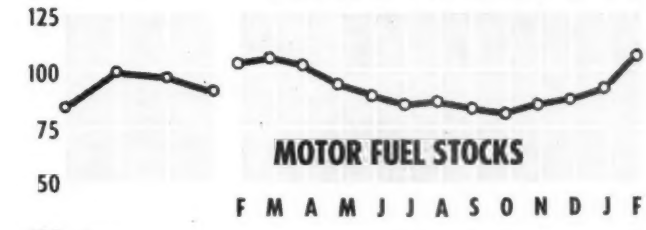
January and February figures are estimates.

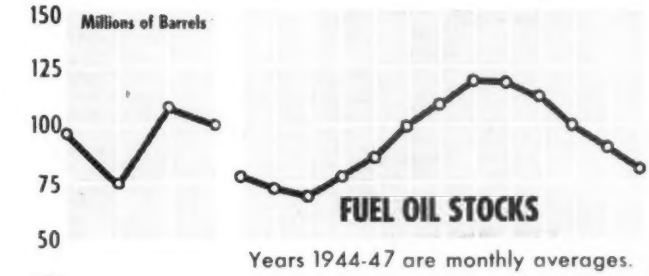












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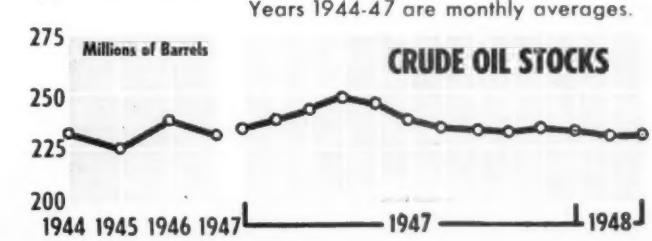

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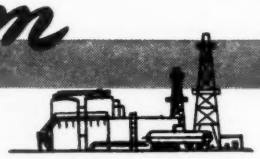


● **RESERVES AT ALL TIME HIGH.** Discovery of new oil pools and extensions of known fields in 1947 increased the nation's proved petroleum reserves by 700,000,000 bbl. Compared with production during the year of approximately 2,000,000,000 (billion) bbl of oil, a total of 2,716,108,000 bbl was found through new discoveries, extensions, and revisions. Proved reserves in the United States were 24,741,660,000 bbl on December 31, 1947, compared to approximately 16,000,000,000 (billion) bbl 10 years ago.

The annual joint report of committees on reserves of the American Petroleum Institute and the American Gas Association issued this month showed the nation's proved petroleum reserves at an all time high. These reserves include crude oil and natural gas liquids, the latter amounting to approximately one-eighth of the total.

As in all previous reports, the joint committees emphasized the fact that their estimates refer solely to "proved" or blocked-out reserves. They include only oil and natural gas liquids recoverable under existing economic and operating conditions. The estimations do *not* include crude oil in the unproved portions of partially developed fields; oil in untested prospects; oil that may be present in regions believed to be favorable; oil that becomes available by secondary-recovery methods; liquid fuels that may become available through chemical processing of natural gas, or synthetic fuels that may be made from coal, shale, or other materials.

In the case of new discoveries, which are seldom fully developed in the first year and in fact for several years thereafter, the estimates of proved reserves necessarily represent but a part of the reserves that may ultimately be assigned to the new reservoirs discovered.

As in the case of the 1946 report, the crude oil reserves were estimated by the American Petroleum Institute committee, the natural gas reserves by the American Gas Association committee, and the natural gas liquids reserves (condensate, natural gasoline, and liquefied petroleum gases) by both committees. The division of these reserves and the production is given in the following table:

Reserves	Dec. 31, 1946	Dec. 31, 1947	Increase, 1947 over 1946
	(Barrels of 42 gal.)		
Crude oil	20,873,560,000	21,487,685,000	614,125,000
Natural gas liquids	3,163,219,000	3,253,975,000	90,756,000
Total	24,036,779,000	24,741,660,000	704,881,000
Production	1946	1947	Increase, 1947 over 1946
Crude oil	1,726,348,000	1,850,445,000	124,097,000
Natural gas liquids	129,262,000	160,782,000	31,520,000
Total	1,855,610,000	2,011,227,000	155,617,000

The corresponding reserves and production of natural gas follow:

	Dec. 31, 1946	Dec. 31, 1947	Increase, 1947 over 1946
	(Millions of cu ft)		
Reserves, natural gas	160,575,901	165,926,914	5,351,103
	1946	1947	Increase, 1947 over 1946
Production, natural gas	4,942,617	5,629,811	687,194

The production figures are net after deducting the amount of gas returned to reservoirs.

● **TO STUDY PETROLEUM'S AVAILABILITY.** The petroleum industry has launched a world-wide investigation into the availability of petroleum products for consumption in the United States for both immediate and future needs, President William R. Boyd, Jr., of the American Petroleum Institute announced.

The subcommittees of the Institute's National Oil Policy Committee will make the studies. The first is instructed to "prepare and to present to the main committee as soon as possible a study based on the best available data on the quantities of various petroleum products available for consumption in the United States during the remainder of the current year and next winter's heating season." The subcommittee will be headed by Howard W. Page, Standard Oil Company (New Jersey), New York.

The second subcommittee has a similar assignment, but on a long-range basis. It is instructed to study the quantities of oil available for consumption in the United States over a period of the next 10 to 15 years. This group will be headed by L. F. McCollum, Continental Oil Company, Ponca City, Oklahoma.

In addition to these committees of the Institute, appointed by the chairman of the National Oil Policy Committee, A. Jacobsen, Amerada Petroleum Corporation, New York, Boyd announced that he had invited the presidents of six other oil trade associations to designate suitable personnel to participate in the discussions and collaborate in the report of Page's committee and to participate in the discussions and report of McCollum's group.

"Mounting demand for petroleum products has given rise to a great deal of public apprehension as to both the short-range and long-range availability of petroleum products for the people of the United States," Boyd said.

"The alarmed prediction that 'we are running out of oil' with which this industry has been confronted since 1860 again is abroad in the land. The uninformed are even setting dates upon which we will run out of oil.

"There is no question that the nation's position in regard to the availability of liquid fuels deserves close attention. These committees, composed of the best informed men in the business, will attempt to evaluate, based upon all data at their command, the exact position of the United States in this regard.

"Their findings will be authoritative. They will constitute a report to the nation of everything the American petroleum industry knows on the subject."

● **NEW PETROLEUM PURCHASING BOARD.** A new board to handle petroleum products buying for the three branches of the armed forces has been established by the Department of Defense. This body, known as the Armed Services Petroleum Board, will replace the joint Army-Navy Petroleum Board, according to Secretary of Defense Forrestal.

The new set-up will differ from the old primarily in that the joint board had no head and accomplished its job mainly through working agreements between the board members themselves.

The new agency will be made up of six members, representatives of the chiefs of staffs of the army and air force and the chief of naval operations, together with representatives from the supply service branches of the three services.

● **ASKS ALASKAN EXPLORATION FUNDS.** Commodore W. G. Greenman, director of naval oil reserves, has asked Congress to appropriate enough money to carry the Navy's Alaskan exploration program through 1953. Com. Greenman told a House armed services subcommittee that oil in commercial quantities had not yet been found in Alaska but discovery of oil-bearing sands had been encouraging.

Funds now available for the project will take it only through 1949, he said, and estimated cost through 1953 would amount to $20,000,000.

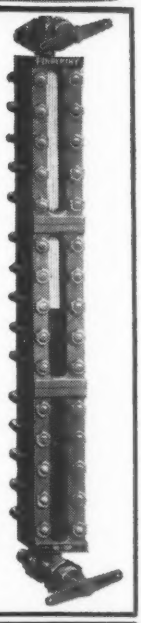
Three wells have been drilled at Umiat, he said, and one yields 24 bbl a day. Other promising tests have been drilled at Cape Simpson.

He said it is believed the Russians are producing oil north of Yakutsk in western Siberia and, if they are, they are drilling on the other side of the basin the Navy is exploring.

PENBERTHY

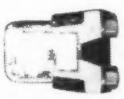
"REFLEX"

DROP FORGED STEEL LIQUID LEVEL GAGES



Liquid always shows black—empty space shows white. Preferred where the liquid level must be easily and positively visible, and when liquids are under high pressure or at high temperature. Made of alloy temperature resisting steel and are highest quality throughout. Liquid chamber made from solid block of steel to assure perfect alignment and rigidity. Conform with A.P.I.—A.S.M.E. requirements.

The "Reflex" is one of the complete line of Penberthy Gages that meet every liquid level gage requirement.



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DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

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"REFLEX"

WATER GAGE SET

For oil field, locomotive type and marine boilers. Water shows black — steam shows white; the water level is unmistakable. U-Bolt construction is strongest and simplest to service. Glass replaced by simply removing nuts on face of gage . . . unnecessary to work between gage and boiler. Conforms with A.S.M.E., Federal and State requirements when used for pressures specified by their respective codes.

This is one of the complete line of Penberthy gages that meet every liquid level gage requirement.

PENBERTHY INJECTOR CO.

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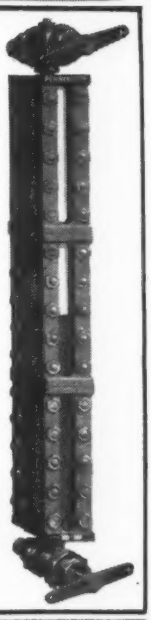
PENBERTHY

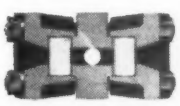
"TRANSPARENT"

DROP FORGED STEEL LIQUID LEVEL GAGES



Used to observe color and density of liquids under high pressures and/or temperatures. Construction exceptionally sturdy. Made of alloy temperature resisting steel, and are highest quality throughout. Liquid chamber made from solid block of steel to assure perfect alignment and rigidity. Conform with A.P.I.—A.S.M.E. requirements.

The "Transparent" is one of the complete line of Penberthy gages that meet every liquid level gage requirement.



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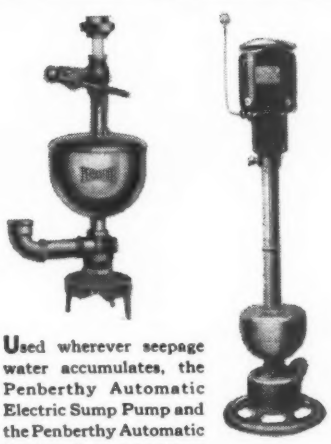
PENBERTHY

SUMP PUMPS



Used wherever seepage water accumulates, the Penberthy Automatic Electric Sump Pump and the Penberthy Automatic Drainer (water or steam operated) have demonstrated their superiority in this service. Simple and rugged design—copper and bronze construction throughout.

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AUTOMATIC INJECTORS

The accepted method for assuring an uninterrupted supply of feed water to oil field boilers. Penberthy Automatic Injectors will supply feed water to boilers at minimum cost, are quickly and easily installed, reliable under most severe operating conditions, require little attention and no careful handling. Highest quality design and rugged construction.

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EJECTORS

Use the power of steam, air or water under pressure to lift liquids. Being simple jet pumps they have no moving parts and require no lubrication. A variety of models to meet different conditions. Also used as water heaters.

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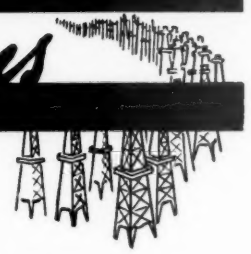
current oil field operations



Exploration wells that have found production.

● **WYOMING.** Ames Management 1 Government C NW SW 1-37n-63w Niobrara. 300-500 BOPD Muddy (Newcastle) 4882 ft.

Texas Unit 1 C NW NE 2-52n-72w Adon structure, Campbell. 200 BOPD 30.8° Converse 8997-9012 ft.

Sinclair Wyoming 22 Witty Unit 1-26n-90w. Sweetwater. 3-hr DST 108 B oil Emsden 6508-55 ft. New sand.

● **KANSAS.** Cities Service 1 Hall "M" SE SE SE 11-12-17w Ellis. 377 BOPD Lansing 3361-512 ft.

M. B. Armer & J. Lindas 1 Hammeke NW NW SE 21-21-12w Stafford. 50 BOPD Arbuckle 3565-76 ft.

Woodriver 1 Ney "A" SW SW NE 31-15-12w Russell. 50 BOPD Lansing 3089 ft.

Woodriver 1 Ney "B" NW NW SE 31-15-12w Russell. 200 BOPD Arbuckle 3345-55 ft.

E. H. Adair 1 Jensen SW SW NE 27-22-4e Marion. 100 BOPD Mississippian chat.

Henderson 1 Keller SW NW NE 5-19s-9w Rice. 1497 BOPD Arbuckle 3246 ft.

Continental 2 Gilbert NE NW SE 6-9s-18w east Barry field, Rooks. 79 BOPD Lansing-Kansas City 3460 ft.

Consolidated Gas Utilities & Anderson-Prichard 1 Frantz NE NE NE 35-20s-2w Sumner. 21 B oil in 12 hr and 5000 MCF gas daily Mississippi lime 3742-79 ft.

Stanolind 1 Trussell 28-26s-39n Hamilton. 1161 MCF gas daily from 2456-80 ft and 2400-32 ft.

● **CALIFORNIA.** Morton & Sons 1 Dominguez Estate, south flank Dominguez Hill field, Los Angeles. Estimate 200-300 BOPD 30° from 7808-8015 ft.

Seaboard 81-80 Pauley-Seaboard 20-3s-14w, Lawndale, Los Angeles. 295 B 60.4° and 4570 MCF gas daily 7990-96 ft.

● **KENTUCKY.** R. Alworth & Ashland 1 Loving 1-K-25 Hopkins. 5000 MCF gas daily from 2220-36 ft.

● **OKLAHOMA.** Deardorff 1 Conners SE NE NW 9-19-7e Creek. DST 125 ft oil Skinner 2612-20 ft.

Gas & Oil Industries 1-B Thompson C N½ SW NW 3-9n-9e, Papoose field. Hughes. 500 ft oil from 3284-322 ft. New sand.

Wilcox 2 Woodward NE NW NE 13-12n-9e Okfuskee. 100 BOPD Wilcox 3907-18 ft.

Carter 1 Bramble NE SW SE 24-4n-3w Garvin. 35-min DST est. 20 BOPH. 4000 MCF gas Bromide 7394-414 ft. New sand.

Magnolia 1-A Miller C NW NE 14-6n-9w, opens West Laverty pool, Caddo. 195 BOPD Marchand 10.630-55 ft.

Sinclair 1 Tulsa University-B NW SE SW 33-3n-2w Southwest Antioch, Garvin. 486 B oil in 23-hr Hunton lime 6756-807 ft.

Sohio 1 Wilfong NW NE SE 34-5-5 Pontotoc. DST 200 ft oil Viola lime 2919-44 ft.

Gulf 1 Foster NW NW SW 4-9n-7e Cheyarha pool, Seminole. DST 40 BOPH Gilcrease 3500-75 ft.

J. E. Crosbie 5 Schultz NE NW SW 30-12n-7e, Garden Grove pool, Okfuskee. 90-min DST gas & 300 ft il Skinner 3182-207 ft. New sand.

Tide Water 1 South Marlow CSE SW 27-2n-7w Stephens. 40-min DST 15000 MCF gas daily and cond from 7897-913 ft.

● **TEXAS.** C. S. Chancellor and Slick 1 Davis 105-8-H&GN, w of Pecos Valley, Pecos. Distillate, 15200 MCF gas daily 9234-84 ft.

Holly Dev. 1 George Stanchos, J. Kelly sur, Dewitt. DST 5 BOPH 35° from 7612 ft.

Pan American 1 Joe Heim, S. Marsh sur, Brazoria. 200 BOPD 29.7° from 9200-06½ ft.

Texas 1-U States, sec 22, blk 40, University Land, Crockett. 2 BOPH Ellenburger 8670-750 ft.

F. M. Manning 4 W. T. Moore-A, sec 2255, TE&L sur, Chaney field, Stephens. 138.74 BOPD Caddo 3322-27 ft. New sand.

T. A. Kirk et al 1 Mears, W. DeMoss sur, Comanche. 308 BOPD Marble Falls 2792-811 ft.

Seaboard 1-B Caldwell, sec 32, blk 32, T&P sur, Howard. 200 BOPD 43° Pennsylvanian 7946-56 ft.

Wrather 1 Varner, Wimberly field, Jones. 8 sands 2100-2557 ft. 45 BOPH King lime 2550-57 ft.

L. W. Barrett 1 McCall, G. J. Cox sur, A-163, Montague. 30 BOPH conglomerate 6400-10 ft.

Continental 1-A-13 University, 13-47-U, Crockett. Swb 156 B oil in 23 hr Silurian 9210-300 ft.

Arrow Drlg & Sells Pet. 1 Allen, Evans sur, Longwood area, Harrison. 148 BOPD 41.8° Travis Peak 6093-105 ft. New Sand.

Humble 1-C Pickering, Rowe sur, Patroon area, Shelby. 1-hr DST gas & 1350 ft 31.8° oil upper Glenrose 5166-260 ft.

McCarthy 1 W. H. Wood, sec 65 T&NO sur, Jefferson. 28 B cond & 2500 MCF gas daily from 10,498 ft.

Anderson-Prichard & Vickers 1 Foster sec 12, blk 13 H&TC sur, Sterling. 21-hr test 736.7 B 28.5° oil Wichita-Albany lime 4252-95 ft.

R-Y 1 J. H. Taylor 133-97-H&TC, Scurry. 87.95 BOPD 28° Clearfork 2925-3176 ft.

Stanolind 3 C. J. Anderson, Whitson area, Matagorda. 182 BOPD 38° from 8570-76 ft. New sand.

Tom Graham 1 Bailey, Agua Dulce farm lot 15, Nueces. 14500 MCF gas daily from 6148-58 ft.

Hiawatha 2-A L. G. Denman, Southwest Texas field, Duval. DST 250 ft oil 5782-84 ft and 800 ft oil 4195-95 ft. New sand.

Humble 2 A. J. Krause, Jourdanton field, Atascosa. 108 BOPD 29.9° from 7155-64 ft. New sand.

C. G. Glasscock & Pontiac Ref. 1 T. A. McDonald, I&GN sur 6, Calhoun. 150 BOPD 41.1° from 7268-69 ft.

L. T. & Bobby Burns 1 Jones, sec 1840, TE&L sur, Archer. Swb 90 B oil in 16 hr Strawn 3209-22 ft.

Superior 2 Fred Wines, Acme field, Clay. 154 B 41° oil in 10 hr from 5857-67 ft. New sand.

J. H. Snowden et al and L. H. Freedman 2 Wright 294-BBB&C, Wright pool, Throckmorton. Flowed oil on 4-min DST Caddo 4241-61 ft. New sand.

Humble 1 J. A. Lutrick C SW SE 14-D8-EL&RR Hale. 165.15 BOPD 24° from 7908-87 ft.

A. O. Phillips 1 Julia Hills, F. H. Votaw sur, Liberty. 141 B 41° oil daily from 5687-92 ft.

Frank & George Frankel 1-C University, sec 25, blk 13, Shafter Lake field, Andrews. 1259.89 BOPD 42° Wolfcamp 8405-45 ft. New sand.

F. M. Manning 1 Davis-Condon 1620-27-TE&L Throckmorton. 28 BOPD Caddo 4175-80 ft.

Stanolind 2 State, tract 2, Gulf of Mexico off High Island, Galveston. DST 1250 ft oil from 6330-60 ft.

Oil Well Drlg. 1 A. P. Allinson sec 1, blk DA-8, GC&SF sur, Edwards. 2-hr DST 100 B oil Ellenburger 4696-715 ft.

S. D. Johnson & Acme Die 1 Scaling 3-HT&B. Clay. Oil from Ordovician 5798-838 ft.

● **INDIANA.** H. L. Cokes et al 1 Heneison SW SW NW 19-5s-11w Vanderburgh. DST oil from Cypress 2341-54 ft and Aux Vases 2622-28 ft.

● **LOUISIANA.** Carter 1 Conway Gandy C SW NW 28-19n-7w Claiborne. Four shows in Cotton Valley 11,002 ft.

Skelly 1 Thelma Nash SW SW NE 20-12n-16w, nw of Logansport field, De Soto. 210 B cond daily 6106-60 ft.

Magnolia 1 McPherson 26-5s-8w Hurricane Creek pool, Beauregard. 120 BOPD 43.8° Cockfield 8415-20 ft.

● **ILLINOIS.** Calvert & Willis and Ashland 1-B Bemis SW SE NE 8-3n-8e Clay. 363 BOPD from McCloskey 3006-42 ft.

Cities Service 1 Bryant CSE SE SW 5-2s-9e Wayne. 60 BOPD Aux Vases 3229-45 ft.

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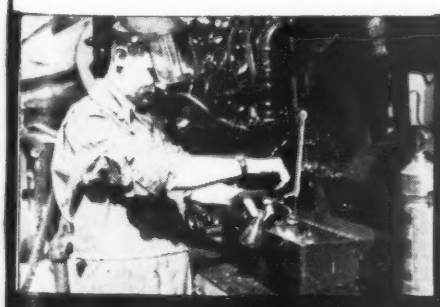

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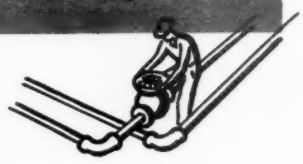
pipeline developments



● **$30,000,000 LINE FOR CANADA.** H. H. Hewetson, president of Imperial Oil, Ltd., announced his company is considering construction of a $30,000,000 pipe line to carry crude oil 500 miles southeast from Edmonton in Alberta to Prairie refining centers at Regina and Moose Jaw.

Plans also include a $20,000,000 exploratory and development well-drilling program for the Leduc-Calmar sector of the Alberta oil field in 1948 and erection of a gas-gathering system and a $1,500,000 gas-absorption plant for the field. Imperial will drill 100 development wells in the field in 1948, he said.

● **TENNESSEE GAS TO EXPAND.** Tennessee Gas Transmission Company will spend another $12,000,000 this summer enlarging its system, President Gardiner Symonds has announced.

The company has received authority from the Federal Power Commission to increase its capacity by another 60,000,000 cu ft daily, he said.

This will be done by laying 150 miles of 30-in. main line loop between Nachitoches, Louisiana, and Portland, Tennessee, and by installing an additional 10,000 hp of compressor engines in five of its existing stations.

● **WORK ON COMPRESSOR PLANT BEGUN.** The Texas Company has awarded a contract to Brown and Root, Inc., to install and construct a compressor plant in the Withers field, 10 miles northeast of El Campo, Wharton County, as the first step in a general program to conserve gas in that area.

Three compressors of 600 hp each, will be installed to compress 9,500,000 cu ft of gas daily. The gas will be used for gas lift purposes and the excess will be disposed of to gas pipe line companies in the area.

The definite program for the gas collection and distribution system in the field has not been outlined yet, because of difficulties experienced in obtaining steel pipe.

● **UNITED GAS TO EXTEND FACILITIES.** United Gas Corporation announced it would begin a $28,000,000 expansion program, which will include extension of supply facilities to more than 27,000 new customers. N. C. McGowen of Shreveport, Louisiana, president, said the expansion would involve expenditure of $8,500,000 for new main transmission lines and $6,500,000 for lease acquisitions, exploratory drilling of gas and oil wells and cycling operations.

He said $3,500,000 had been earmarked for a new gasoline plant at Carthage, Panola County, Texas.

● **TO BEGIN RANGELY LINE SOON.** By the end of the year Standard Oil of California expects to complete its pipe line from Rangely field, Rio Blanco County, Colorado, to refineries at Salt Lake City, Utah. The line will traverse Wolf Creek Pass, northwest of Duchesne, Utah, at an elevation of 9480 ft, which makes the line the highest in the United States. Construction will begin as soon as weather conditions are more favorable. The cost is expected to run about $5,500,000. The project will be operated by the Salt Lake Pipe Line Company, a newly organized subsidiary of Standard of California.

Initial capacity of the line will be 25,000 bbl of oil a day, with possibility of increasing to 35,000 bbl if needed.

● **EASTERN LINE SCHEDULED.** Socony-Vacuum Oil Company in May will begin work on a 125-mile 6-in. pipe line from South Portland Maine, to Bangor, serving Auburn and Hallowell en route. The work is expected to be completed in July.

● **PLANS INCH LINES EXPANSION.** Texas Eastern Transmission Corporation, Shreveport, Louisiana, applied to the power commission for authority to install an additional 114,000-hp in compressor stations on the Big and Little Big Inch pipe lines.

The company estimated that additional horsepower would increase delivery capacity from 433,000,000 to 508,000,000 cu ft daily. The installation cost, about $8,983,900, would bring the total cost of the pipe line system to $181,390,900.

Texas Eastern said it has agreed to deliver 75,000,000 cu ft of natural gas daily to the East Ohio Gas Company, Cleveland, and the Peoples Natural Gas Company and New York State Natural Gas Corporation, both of Pittsburgh.

● **WANTS TO BOOST GAS SUPPLY TO WEST.** El Paso Natural Gas Company has requested permission from FPC to build a $81,101,200 pipe line project to increase natural gas supply in California.

The pipe lines, designed to carry an additional 300,000,000 cu ft of natural gas a day, would be completed by November, 1950, or shortly thereafter, according to the company proposals.

The present application, which is a substitute for a previous one, includes plans for a pipe line from Lea county, New Mexico, to a point near Blythe, California, and a second line from San Juan county, New Mexico, to the vicinity of Needles, California.

● **FPC HEARING PROCEEDINGS.** Trans-Continental Gas Pipeline Company's application to build a $150,000,000 natural gas system from Texas to the Eastern Seaboard is being heard before FPC beginning March 22.

The date was set to speed final decision on the case, and usual intermediate procedures will be omitted. Hearings have been in progress since October. Testimony by opponents of the 1839-mile line began February 12.

The application is opposed by Texas Eastern Transmission Corporation, purchaser of the Big and Little Inch pipe lines, and Tom J. McGrath, of the National Coal Association.

● **ANOTHER INCH CONNECTION.** The East Ohio Gas Company has begun construction of about 84 miles of 20-in. pipe line extending from a connection with Texas Eastern Transmission Corporation's Inch lines at East Ohio's Mullett Farm valve station to its Gross Farm valve station near Canton, Ohio. Cost of the facilities has been estimated at $3,200,000. The maximum capacity of the line is estimated to be about 130,000,000 cu ft of natural gas daily.

● **COMPRESSOR STATION TO BE ADDED.** Michigan Gas Storage Company will construct a compressor station on Panhandle Eastern Pipe Line Company's North Line near Flint, Michigan. The station would consist of four compressor units of 1000 hp each and associated auxiliary equipment. Construction costs have been estimated at $559,400. Capacity of the line upon which it would be installed would be increased by about 24,000,000 cu ft per day, the company stated. Construction is expected to be completed by May 1.

● **PLAN WYOMING CARRIER.** Frontier Refining Company has applied for a permit to build a 65-mile pipe line from the Mush Creek and Ant Hill fields in Weston County, Wyoming, to a terminal of the Rocky Mountain Pipe Line Company's line near Lusk, Wyoming. Line will cost $750,000.

● **TRANS-ARABIAN LINE PROGRESSES.** Since 875 miles of the 1075-mile pipe line route lie within Saudi Arabia, delays on the Mediterranean end are not expected to affect the completion date for the Trans-Arabian pipe line, it was stated by B. E. Hull, president of the Trans-Arabian Pipe Line Company. It still is planned to finish the line as originally scheduled in 1950. Thereafter the line will be used to transport more than 300,000 bbl of oil per day toward Europe.

Stable conditions prevailing within Saudi Arabia are reflected in current field reports of steady progress in construction of the off-loading terminal at Ras el Misha'ab on the upper Persian Gulf Coast. The field base camp at this point, designed to accommodate 600 Americans, is 80 per cent complete.

Three to five 30-ft lengths of pipe are being welded into 90-ft to 150-ft lengths before stringing. The Ras el Misha'ab pipe-joining plant, where pipe can be welded automatically, has been completed and is in operation.

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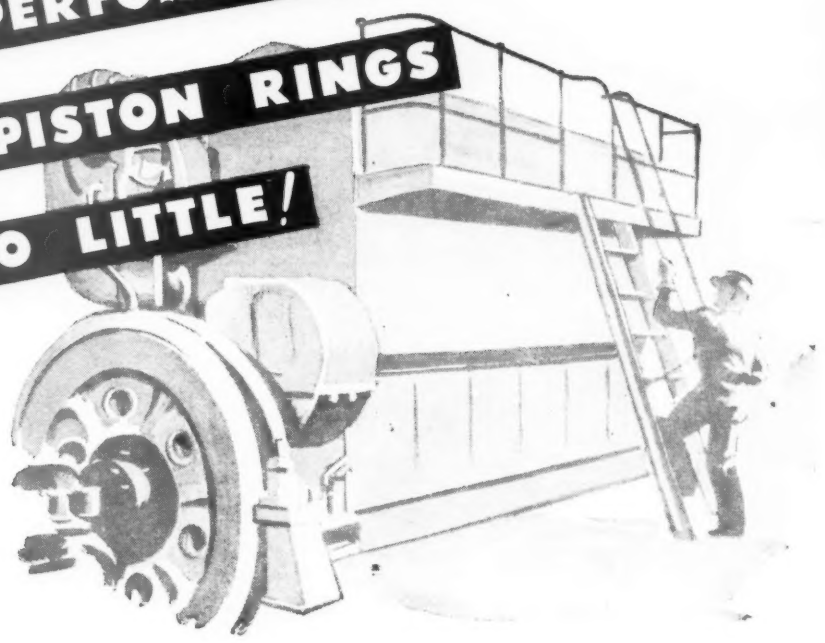

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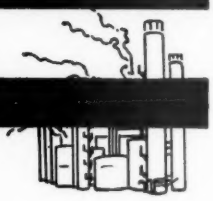


● **WORK BEGUN ON STANOLIND PLANT.** Garden City, Kansas, has been selected by Stanolind Oil and Gas Company as the site for its multi-million dollar synthesis plant that will convert natural gas into liquid fuels and chemicals, E. F. Bullard, president, announced.

Stanolind's plant will take natural gas from the Hugoton field, some of which is not desirable for sale because of its low Btu content, and will convert it into synthetic gasoline, diesel fuel, fuel oils, and useful chemicals.

During the height of construction, Stanolind engineers estimate that nearly 4000 workers will be required on the project. They are hopeful that the plant can be completed and in production by January, 1950. A permanent force of about 600 will be needed to operate the plant.

The gasoline and fuel oils produced at the plant will be marketed largely in the Kansas area. The chemicals produced will be distributed by U. S. Industrial Chemicals, Inc., throughout the country.

Bullard said that many major pieces of equipment are already being fabricated and that more than 200,000 tons of equipment and material will be brought to the site during the construction period. As part of the project, the largest oxygen plant in America will be built at the site to supply oxygen for the process. The plant power house will have a generating capacity large enough to supply electricity for an average city of 50,000 population.

This big project will include a natural gasoline plant to extract liquefiable hydrocarbons such as gasoline, butane, and propane from the natural gas; the synthesis plant itself including the oxygen production unit; a chemical refining unit; power plant; office building; laboratory and many auxiliary buildings.

● **CALIFORNIA PLANT BEGINS ADDITIONS.** Standard Oil Company of California has authorized Universal Oil Products Company to design a two-coil thermal cracking unit of the latest design, with stabilizer and other auxiliaries, and a Unisol unit to extract mercaptans from the cracked gasoline.

Both units are to be installed in the Standard Bakersfield, California, refinery, as part of a program of expansion and modernization of that plant. The cracker is to be designed to process 9000 bbl per day of heavy oils. C. F. Braun Company, of Alhambra, California, are the general contractors.

● **SYNTHETIC PLANT REPORTED.** New Mexico is being considered as a possible site for a government-owned commercial-size synthetic liquid fuel plant, it is reported. James Boyd, director of the Bureau of Mines, was quoted as saying that laboratory tests were made of samples of New Mexico coal, and that it was found suitable for conversion into liquid fuels by the hydrogenation process.

New Mexico coal reserves are estimated at 22,000,000,000 tons, Chavez said.

● **UTAH REFINERY TO BE COMPLETED IN 1948.** Standard of California expects to complete its new oil refinery in North Salt Lake, Utah, this year. The $5,000,000 plant will process Rangely crude to be carried by the pipe line scheduled for construction this year. (See Pipe Line page). Capacity of the plant, to be built by Bechtel Company of San Francisco, will be 15,000 bbl of crude oil a day.

● **MAGNOLIA PLANS OUTLINED.** R. D. Handley, manager of Magnolia Petroleum Company's natural gas division, told the Kansas Corporation Commission the cost of a proposed gasoline extraction plant in Grant County, Kansas, would cost as much as $2,800,000 and the system of gathering lines for the plant would cost perhaps $1,800,000. The plant itself, he added, would cost from $850,000 to $1,000,000, and would be completed by October, this year. Already 55 of the 63 wells in the Hugoton gas field to serve the plant are drilled or nearly completed.

The plant would be operated by from 15 to 20 employes, would process about 60,000,000 cu ft of natural gas a day, and would produce 19,000 gal of high grade natural gasoline and 15,000 gal of lower grade liquefied petroleum gases daily, he added. Marketing residual dry gas to Cities Service Gas Company lines, he said, the plant could peak to 100,000,000 cu ft of gas daily if needed.

The gathering system, already started, will include 150 to 170 miles of pipe, ranging from 4-in. diameter to 24-in.

● **REPUBLIC BUYS TEXAS CITY PLANT.** Sale of a Texas City, Texas, aviation gasoline plant for $2,300,000 to the Republic Oil Refining Company, wartime operator of the plant, has been approved by War Assets Administration.

The property, having an appraised fair value of $2,543,000, includes a fluid catalytic cracking unit, gas concentration unit, alkylation unit, thermal reforming unit, and gas distillation unit. Under sale terms, Republic will expend or commit itself to expend $250,000 in six months and an additional $250,000 within one year for repair, restoration, and rehabilitation of the refinery and shall have exclusive right to buy all or any part of the furniture and machines, laboratory equipment, spare parts, operating supplies, and fire fighting equipment on the property.

● **ROCK ISLAND REFINING TO INSTALL UNIT.** L. E. Winkler, president, Rock Island Refining Corporation, Indianapolis, Indiana, has just announced that his company has entered into an agreement with Universal Oil Products Company, Chicago, for the design and engineering of a fluid catalytic cracking unit which is to be installed in the Rock Island Refinery at Rock Island (near Indianapolis), Indiana.

The unit that Rock Island will install is to be designed for a capacity of 5000 bbl per day of Mid-Continent type gas oil at 54 per cent conversion. This is essentially the same type unit that Universal designed, and that has been on stream at the refinery of Aurora Gasoline Company, Detroit, since the summer of 1947.

The unit for Rock Island will be so designed that it will utilize to the fullest extent the already existing thermal cracking unit and gas recovery system. Feed preparation equipment for supplying charge to the catalytic cracker is already in place and will be a part of the new fluid unit.

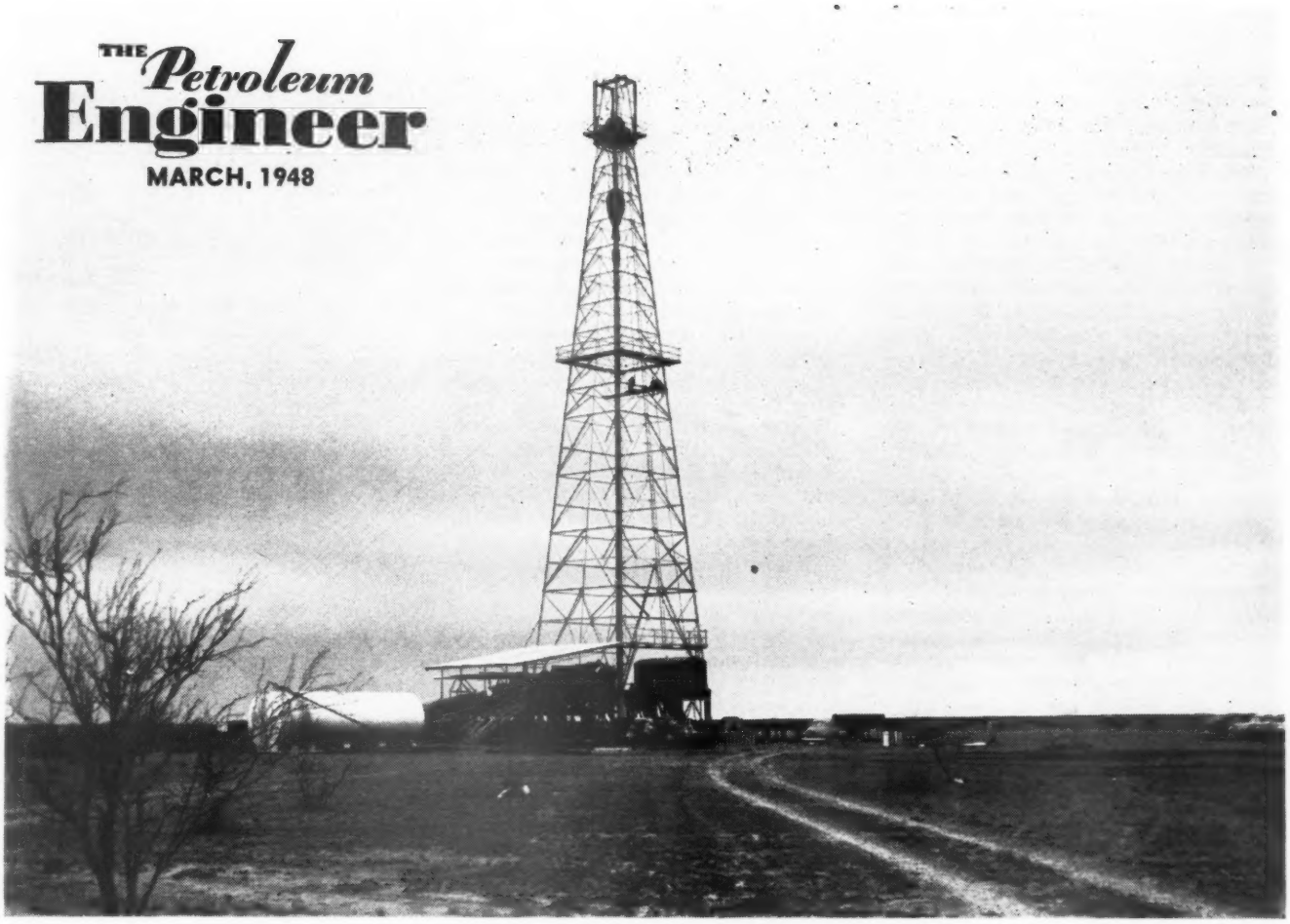
● **LION OIL BUYS CHEMICAL PLANT.** Lion Oil Company purchased from the United States government the chemical plant near El Dorado, Arkansas. The plant, formerly known as Ozark Ordnance Works, is one of the largest United States producers of anhydrous ammonia, ammonium nitrate fertilizer, and nitrogen fertilizer solutions. During the period from May 1943 until May 13, 1946, Lion Oil Company, through a wholly-owned subsidiary, operated this plant for the government. Then the company took over the plant for private operation under a long-term lease and has been operating it continuously since that time.

According to T. H. Barton, chairman of the board, outright purchase of the plant will permit greater flexibility in the operation of these facilities and make the plant more readily available for capital additions and expansion which may be expected in the long-term growth and development of the chemical division of the company.

● **CYCLING PLANTS.** A permit to cycle the 7650-ft gas sand in the Francitas field, Jackson County, Texas, has been issued to the Francitas Gas Company by the Texas Railroad Commission.

Western Natural Gas Company was authorized by the Commission to operate a cycling plant in Goebel field, Live Oak County. It will process gas from five wells in the Luling sand, and return residue gas to the reservoir.

THE Petroleum Engineer
MARCH, 1948



A heavy-duty rotary rig is preparing to drill the north offset to the 12,022-ft discovery well of the Benedum field.

Benedum Ellenburger field developments

By K. MARSHALL FAGIN, *Field Editor*

Now that the smoke of excitement over the recent discovery of petroleum from a thick section of Ellenburger dolomite in Slick-Urschel and Plymouth's 12,022-ft Alford well has cleared a little, the leaseholders in the Benedum field area of Upton and Reagan counties, Texas, are busy staking locations, seeking pipe and other material and equipment needed for drilling and equipping deep, high pressure wells, moving into the area, rigging up, and spudding into the earth in a spreading search for crude oil.

EXCLUSIVE

The Alford well was begun on May 29, 1941, by the Plymouth Oil Company. It was located on an anticlinal structure about 10 miles northwest of Big Lake field that was indicated by seismograph exploration. Casing of 16-in. diam was set and cemented with 200 sacks at 308 ft, 10¾-in. casing was set and cemented with 1700 sacks at 3599 ft, and 7-in. casing was set and cemented with 700 sacks at 9750 ft. A hundred sacks more were squeezed below the casing shoe using a drillable cement retainer. Five more 75-sack batches were squeezed below the shoe using a retrievable cement retainer* and allowing a 12-hr interval between batches. Difficulty with caving of a thick black shale section above the Devonian caused the operators to set a 5½-in. liner from 9675 to 10,000 ft with 300 sacks of cement with a special duplex float shoe.

*This is reported to be the first Baker retrievable cement retainer used in West Texas.

The well was cored from 10,130 to 10,145 ft, and about 3 ft of coarse crystalline white glauconitic lime with a slight odor of sweet gas and a slight stain of oil was recovered. A 90-min drillstem test from 10,100 to 10,271 ft yielded a light blow of air during the first few minutes and again during the last 60 min. A 1000-ft water cushion was used, and recovery was 1092 ft of sweet gas-cut mud and water cushion through a ½-in. bottom hole choke and a 1½-in. top choke. No salt water was found.

The well was then temporarily abandoned on May 5, 1942, at a total depth of 10,384 ft in lime and chert. A temperature survey was run on January 25, 1946, from 2000 to 9805 ft in an effort to find out where gas was entering the

casing. The well was next worked over in September, 1946. Another drillstem test between 10,205 and 10,384 ft gave indications of a small volume of gas. The casing was then perforated from 9660 to 9695 ft with 210 shots. A 3-hr drillstem test yielded gas in 11 min and a "good blow" throughout, estimated as 1000 to 15,000 cu ft per day. Recovery was 2160 ft of gas-cut, blue, fresh-water drilling mud.

A second 3-hr drillstem test was made through the same perforations, and the recovery was 2250 ft of gas-cut mud and water. The well was temporarily abandoned again on September 27, 1946, at a plugged-back total depth of 9734 ft. A double-pin sub and roller tool had been lost in the hole before it was plugged back to 9734 ft from 10,394 ft.

Slick-Urschel took over the well on a farmout deal from Plymouth Oil and Fred Turner and re-entered it on June 16, 1947, to sidetrack the lower part of the hole and drill to the Ellenburger. A whipstock was set between 8504 and 8522 ft and a 6⅛-in. window was milled through the 7-in. casing. The window was reamed and a new 6⅛-in. hole was drilled directionally to the final total depth of 12,022 ft, where it was cased with string of 5-in. 18-lb extreme line casing, and cemented with 80 sacks of cement. The casing shoe was bottomed at 12,018 ft, or 4 ft off bottom.

Casing was perforated for production with 250 shots from 11,885 to 11,910 ft; 11,945 to 11,960 ft, and 11,975 to 11,985 ft in the Ellenburger formation. After a 1500-gal acid treatment, the well was finally recompleted on an official Railroad Commission test on January 4, 1948, for an initial production of 833 bbl per day through a ¾-in. choke and a 12,011-ft string of 2-in. tubing with a subsurface regulator at 10,020 ft. The casing pressure was about 650 psig and the tubing pressure about 2400 psig while the well was flowing. The gas-oil ratio was recorded, and reported to be calculated at about 4400 cu ft per bbl. The oil was reported to be about 56 deg API gravity. The subsurface regulator had a maximum opening of ½-in.

The successful casing and recompleting of this well in about 190 days through a 3500-ft section of sidetracked hole 6⅛-in. in diam marked a monumental achievement in modern drilling practice, although the total cost of the completed well was estimated to be about $980,000. Part of this high cost was caused by the natural difficulties encountered in keeping the sidetracked section of the hole fairly straight by frequent plugback jobs, use of removable whipstocks, and deviation surveys. The new section of hole below the whipstock was drilled directionally away from the old hole with a maximum drift of 8 deg from vertical to 9410 ft. From that point to about 10,000 ft, the hole was allowed to drift back to vertical.

About 125 bits were used to complete the drilling of the 3500-ft sidetracked section of the hole using an average of 18,000 lb of drill collars and 50 rpm rotary speed. The thick black shale section above the Devonian formation was penetrated without much difficulty from heaving or caving, due to careful conditioning of the drilling mud with bentonitic material, caustic soda, and quebracho. The weight of the mud was kept between 10.5 to 11 lb per gal by the addition of powdered barytes, and the water loss was kept to about 6 cc or less most of the time. The viscosity of the drilling mud was raised from about 50 to 150 sec while the gel strength was kept low. The filter cake was maintained at about 1/16-in., and very little difficulty was experienced with loss of circulation.

Some mud loss occurred after the 5-in. casing was run to 12,018 ft and circulation could not be established. Porous and permeable sections near bottom or

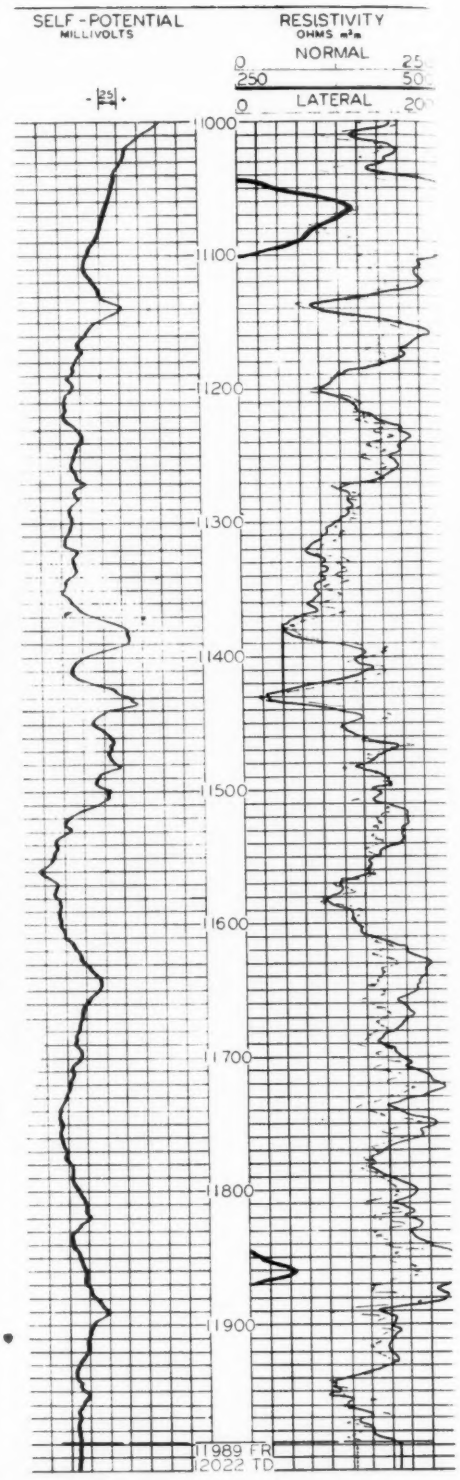
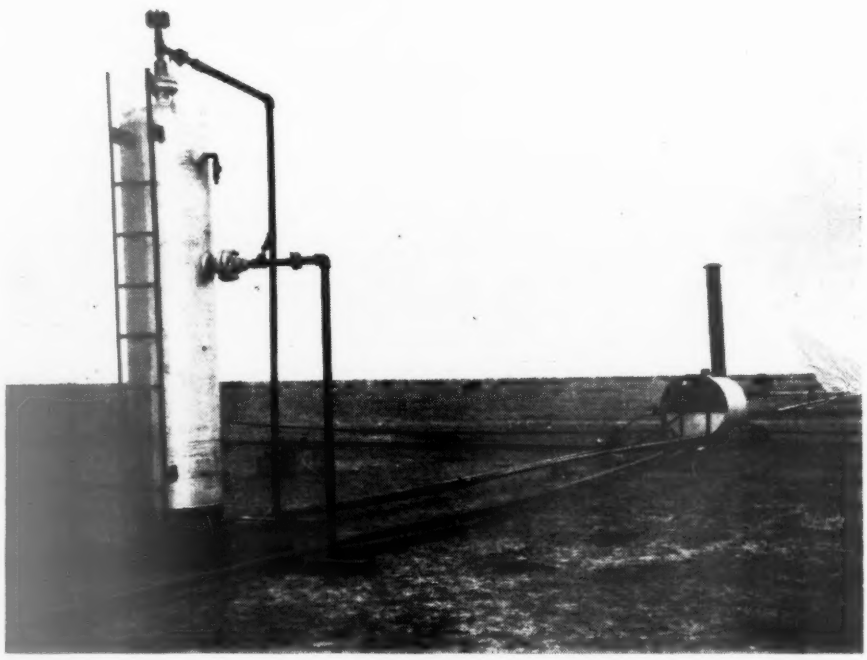


FIG. 1. Electric log of the Ellenburger section of Slick-Urschel's Alford No. 1.



A 2½ by 13-ft, 1000-psig test separator receives well fluids at about 700 psig from the heater equipped with a ½-in. choke (right). Production from the well is delivered to the heater at 1500 to 1800 psig through the high pressure 2½-in. line pipe.

behind the casing were apparently taking the drilling mud at some pressure lower than the weight of a full column of 10-lb mud, which is equivalent to about 6250 psig at 12,000 ft. The initial Ellenburger reservoir pressure was later determined to be 5225 psig by a pressure bomb test. In other words, some of the drilling mud apparently entered the reservoir with less than a 1025-psig differential between the reservoir pressure and the pressure of the column of 10-lb mud.

Cementing the 5-in. string with a 12,000-ft column of mud down the casing ahead of the cement might have resulted in forcing as much as 250 bbl of mud into the formation ahead of the cement. It was therefore decided to cement the casing through a string of 2-in. tubing with a magnesium-type cement retainer* set a short distance above the float collar. This method enabled the operators to place the 80-sack batch of slurry behind the casing without pumping more than 30 bbl of mud into the formation ahead of it.

A temperature survey indicated the top of the cement behind the pipe was about 10,820 ft. Following this operation, the casing was perforated above this depth, and additional cement was displaced behind the pipe with full top hole returns of drilling mud. A junk basket* and casing scraper* were used subsequently in drilling out and cleaning the casing for completion.

After perforating three sections of the casing from 11,885 to 11,985 ft, the well was swabbed, acidized with 1500 gal of 20 per cent acid for 11 hr, and swabbed again. It soon began to flow, and produced about 50 bbl per hr for 5 hr through a 1-in. choke.

*Manufactured by Baker Oil Tools, Inc.

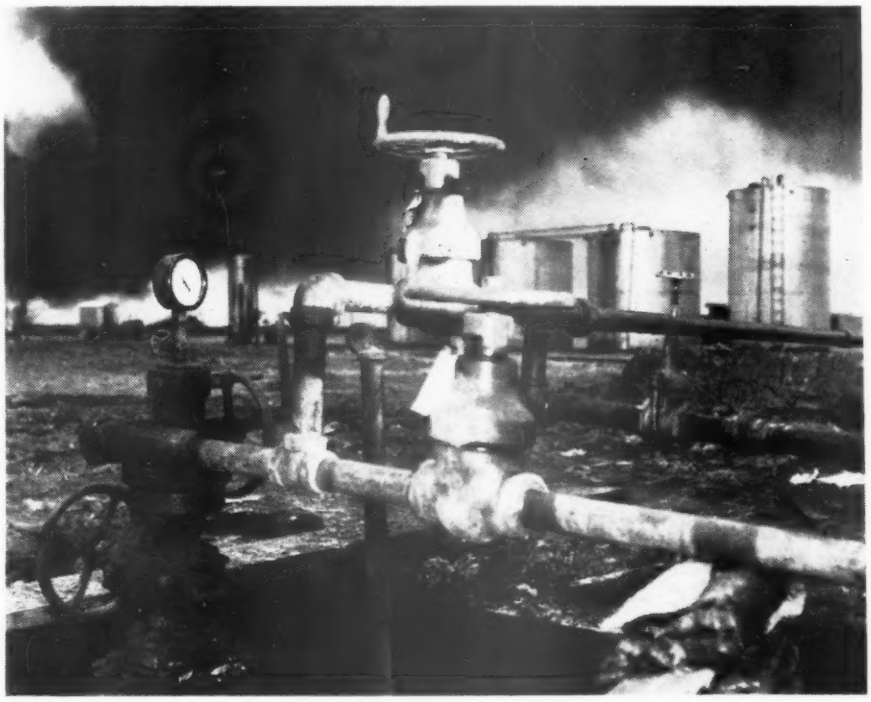
Due to the unusual hazards connected with drilling such a long and small diameter sidetracked hole through such hard cherts and limestones, and such thick shale formations, the drilling was conducted with great caution, and coring was ruled out as too hazardous. For the same reason, several oil and gas showings in the Devonian and Silurian formations were not drillstem tested.

One drillstem test was made in the Pennsylvanian, however, from 9410 to 9494 ft, and 15 were made in the Ellenburger. The test in the Pennsylvanian produced gas at the surface in 15 min, and recovery was 4800 ft of 40 deg API gravity oil, 1300 ft of oil-cut mud, and a 1500-ft water cushion in 4 hr through a 1-in top choke and 5/8-in. bottom choke. Four of the tests in the Ellenburger failed, and 11 yielded gas and various amounts of oil or condensate. The lowest gravity reported for any of the Ellenburger oil on these tests was about 53 deg API. About 2500 ft of such oil was recovered on a test from 11,587 to 11,684 ft. About 200 ft of salt water was also recovered on that test.

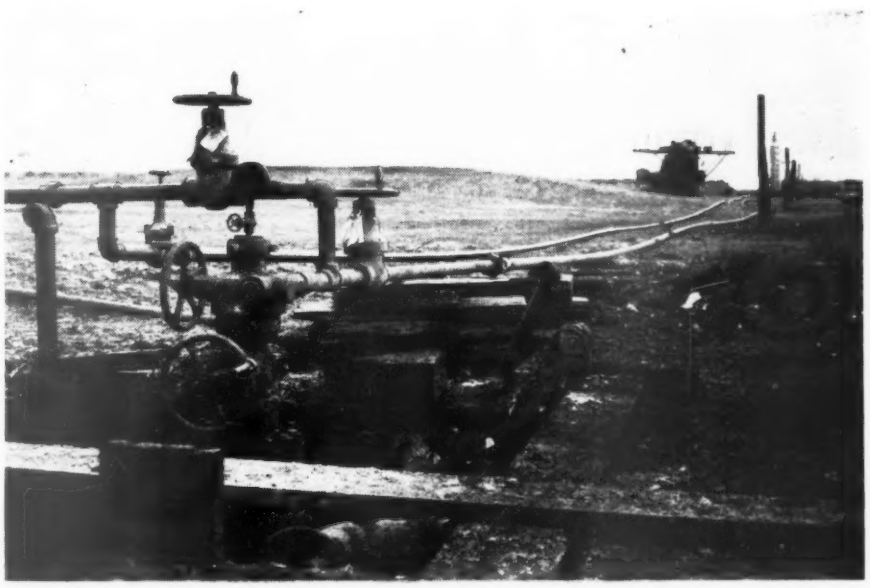
Figs. 1 and 2 show the electric log and a composite engineering log* through the Ellenburger section of the well, which was topped at 11,020 ft and not penetrated completely. The drilling time curve of Fig. 2 indicates that the Ellenburger was drilled at an average rate of about 22 min per ft. Twenty-eight new bits were used in drilling this 1000-ft section of the Ellenburger dolomite. The leached residual oil curve was obtained by applying solvents to the drill cuttings and evaluating the residual liquid hydrocarbon collected on color reaction plates.

The two gas curves were obtained by analyzing the cuttings for combustible gases. The dotted curve represents the total combustible gases, including methane. The dashed curve represents all

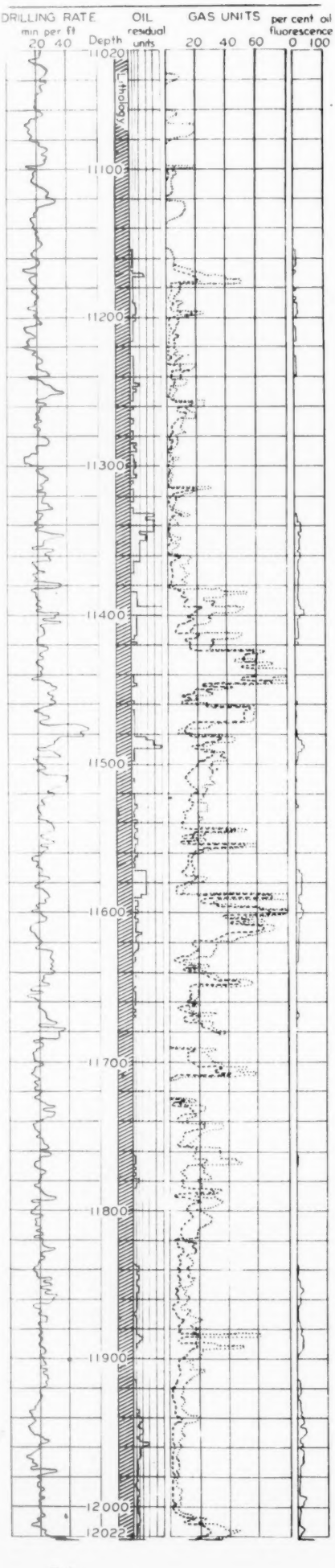
*Prepared for the operators by Rotary Engineering Company, Midland, Texas.



The pressure gauge on Slick-Urschel's Alford No. 1 registered 1800 psig while flowing at the rate of 700 bbl per day. Low-pressure separator and tank battery are seen in the background.



A temporary flow line carries production to the heater and high-pressure separator (upper right). The parallel line returns the separated petroleum to the low-pressure flow line.



combustible gases, excluding methane. The righthand curve represents the per cent of the samples that showed fluoresence. Analyses in a portable laboratory were made of the cuttings from each 2 ft of hole that was drilled, and corrections were made for the time required for the cuttings to reach the surface in the drilling mud stream.

Although the drillstem tests indicated that the permeable sections of the Ellenburger would yield only gas or gas and condensate, the composite engineering log was interpreted as indicating the possibility of crude oil production from three sections as follows: 11,330 to 11,380 ft; 11,482 to 11,492 ft. and 11,520 to 11,588 ft. The section from 11,636 to 11,838 ft was believed to be "too impervious to take acid" and unlikely to yield much oil or gas. A water-bearing zone was believed to be indicated between 11,672 and 11,724 ft in this section. This interpretation would indicate that 128 ft of the 1002 ft of Ellenburger penetrated in this well might yield oil; 246 ft might be barren, and 628 ft would probably yield gas and condensate.

Until further production tests are made of the upper zones in this well, which are now cased off, the interpretations related above should be judged carefully in the light of the drillstem test data that failed to indicate dark crude oil production. The light yellowish-green 56 deg API oil that is being produced from the lower part of the penetrated section of Ellenburger has a low gas-oil ratio (4400 cu ft per bbl), and contains a considerable amount of paraffin, suggesting that it may be a mixture of oil and condensate. Experence with production from the Ellenburger formation in Big Lake makes this a reasonable explanation.

Although the Benedum Ellenburger field may not be comparable to the Big Lake Ellenburger field, it might be worthwhile for the reader to review the history and production record of the Big Lake Ellenburger field, and make a few tentative comparisons. The Ellenburger reservoir of the Big Lake field covers a proved area of about 1300 acres. It is known as the "8500-ft" producing zone, and it is a gray limestone and crystalline dolomite reservoir of moderate hardness except for some extremely hard streaks. It is known to be more than 650 ft in thickness.

The discovery well, Continental Group I's University No. 1-B, was completed on December 1, 1928, with cable tools at a total depth of 8525 ft for an initial production of 40 bbl of 57.7 deg API gravity oil and 500,000 cu ft of gas. This indicates that the gas-oil ratio was 12,500 cu ft per bbl, or almost three times the ratio of the Benedum discovery. The initial reservoir pressure was estimated to have been 3600 psig at 8300 ft, or a normal gradient of 0.43 lb per ft of depth. The Alford well has a measured initial reservoir pressure of 5225 psig at 12,000 ft, which is also normal for a column of fresh water that deep. The reservoir temperatures are: Big Lake, 8300 ft, 170 F; and Benedum, 12,000 ft, 186 F.

University No. 1-B was completed with 2347 ft of open hole below a string of 5-3/16-in. casing set at 6176 ft, and as the well was produced under open flow conditions, the gas and oil production increased to a peak of about 2900 bbl and 27,000,000 cu ft per day in July, 1930, about 18 months after it was completed. The ratio at this peak rate, however, was only 9500 cu ft per bbl, or

FIG. 2. Composite engineering log of the Ellenburger section of Alford No. 1, showing the drilling rate, depth, lithology (all of the Ellenburger is logged as dolomite), leached residual oil units, combustible gas units in the cuttings, and the percentage of fluoresence due to oil in the samples. Table 1 (above) is data taken from a part of this log that is not shown. Also, not shown, is the bit record.

TABLE 1. Drilling mud test data, Alford No. 1

Drilling depth, ft	Weight, lb/gal	Viscosity, sec	Water loss, cc	Filter cake, in.	pH
10,066	10.5	134	6.0	2/32	8.5
10,200	10.3	146	5.5	2/32	10.0
10,324	10.4	158	6.0	2/32	9.5
10,370	10.6	160	6.0	3/32	9.0
10,612	10.6	154	7.0	3/32	7.5
10,700	10.7	165	6.0	3/32	7.5
10,944	10.8	192	6.0	3/32	8.0
11,060	10.8	180	5.0	3/32	8.0
11,120	10.9	185	6.0	2/32	9.0
11,240	10.8	138	5.0	2/32	9.0
11,260	10.8	160	5.0	2/32	9.0
11,290	10.6	230	6.0	3/32	9.0
11,304	10.9	175	6.0	3/32	9.0
11,340	10.9	145	6.0	3/32	9.0
11,374	10.8	92	5.0	2/32	9.0
11,400	10.7	168	7.0	2/32	9.0
11,410	11.0		6.0	2/32	9.0
11,422	10.8	110	6.0	2/32	10.0
11,452	10.6	250	5.0	2/32	9.0
11,468	11.0	234	6.0	3/32	9.0
11,490	10.9	182	6.0	3/32	9.0
11,508	11.0	220	5.0	3/32	9.0
11,540	11.0	163	7.0	3/32	8.5
11,557	11.2	223	6.0	3/32	8.5
11,580	10.8	237	6.0	3/32	9.0
11,600	10.9	202	6.0	3/32	8.5
11,638	11.4	320	6.0	3/32	8.0
11,680	11.1	340	6.0	3/32	9.0
11,716	11.0	250	7.6	3/32	9.0
11,758	11.0	180	6.2	3/32	9.0
11,775	10.9	312	6.0	3/32	8.5
11,816	10.8		5.8	2/32	8.5
11,848	11.0	230	6.0	2/32	8.0
11,904	10.8	180	6.0	2/32	8.5
11,928	10.9	240	5.0	2/32	8.5
11,972	10.9	215	5.8	2/32	8.5
12,006	10.7	252	4.9	2/32	8.0
12,020	11.2	190	6.0	2/32	8.5

TABLE 2. Top of formations in Alford No. 1, elevation 2669 ft.

Name of formation	Depth to top, ft	Distance from sea level, ft
Anhydrite	1,250	+1419
Salt	1,310	+1359
Yates sand	2,110	+ 559
Grayburg	3,590	- 921
Devonian	10,016	7347
Silurian	10,590	7921
Simpson	10,795	8126
Ellenburger*	11,020	8351

*Well drilled to total depth of 12,022 ft in the Ellenburger formation.

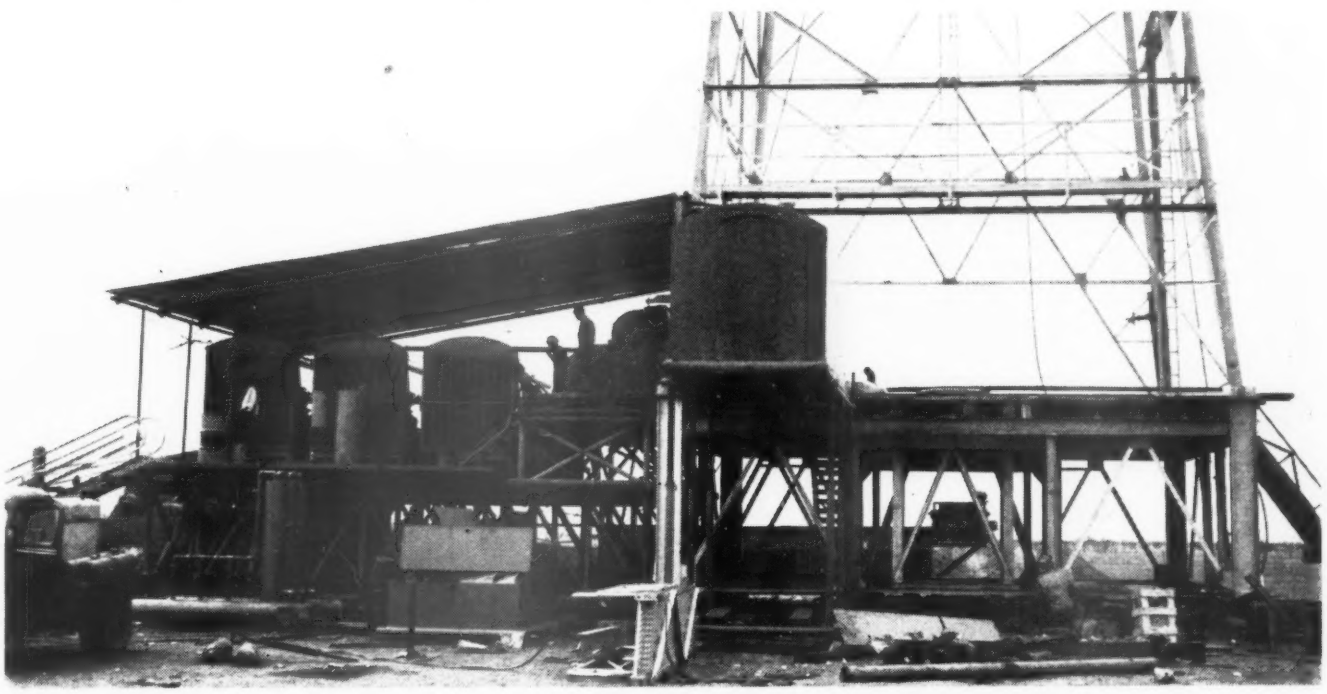
A 3-in. pipe line from Slick-Urschel's Alford tank battery (upper right) is now connected to Shell's new 8-in. pipe line laid in a ditch (foreground) to one of its main lines about 10 miles away. Plymouth Oil Company's Wallace No. 1 (derrick on horizon) was rigging up when this photgraph was taken. Paraffin from the Alford tank battery had just been ignited in a burn pit, causing the huge pillar of black smoke.

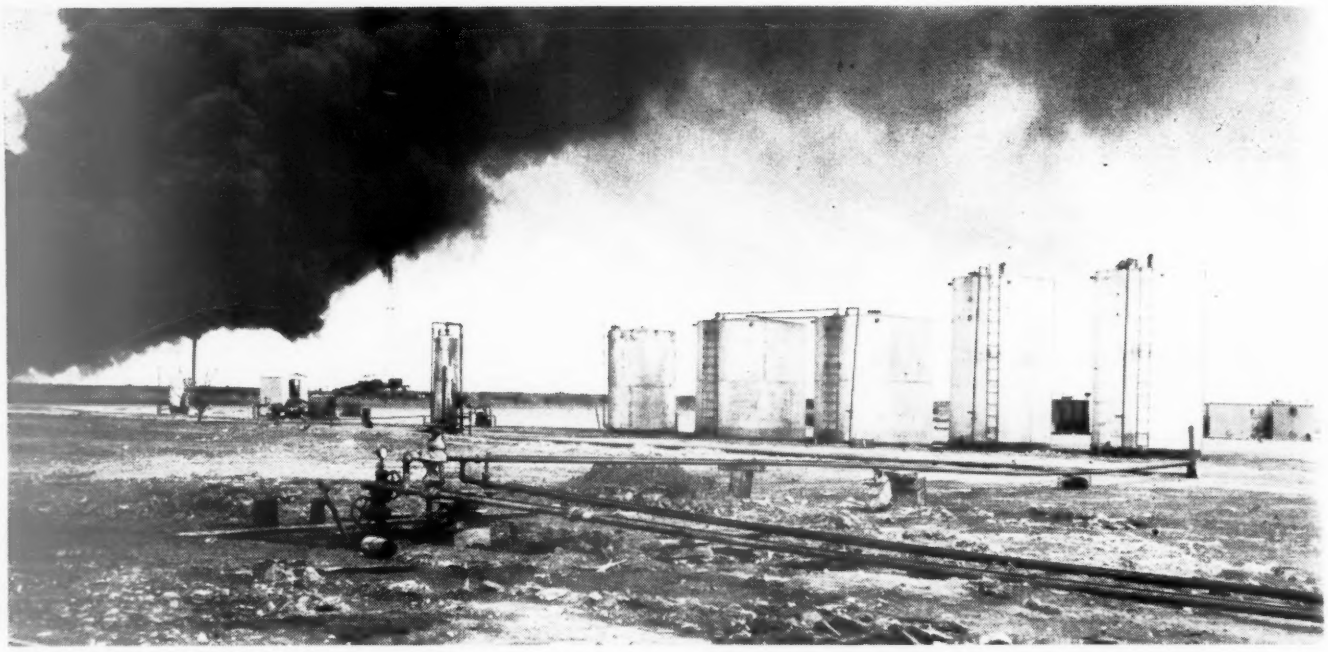
3000 cu ft per bbl less than the initial ratio. By that time other wells had been completed in the Ellenburger, and the production from the discovery well began to decline. It had produced a total of 2,651,138 bbl by December 18, 1931, but it had declined so much by March, 1932, that it was drilled deeper. This did not result in much more production, and it was shut in early in 1933 after water began to appear.

The second well was completed in the Big Lake Ellenburger field in October, 1929, at a depth of 8379 ft for an initial production of 190 bbl and 5,000,000 cu ft per day, or a ratio of 26,400 cu ft per bbl. The third well was completed about 30 days later at a depth of 8220 ft with an initial production of 327 bbl and 6,000,000 cu ft per day, or a ratio of 18,300 cu ft per bbl. By January 1, 1936, 25 wells had been completed in the Ellenburger reservoir at Big Lake. Initial production ranged from 160 to 6000 bbl a day from depths of 8131 to 8926 ft. Most of the later wells were drilled in with rotary rigs while producing gas and "water white" oil. This method prevented the possibility of mudding off any of the permeable producing zones in the reservoir. It also enabled the operators to determine the approximate contact between an upper zone that contained high-ratio water white oil and a lower zone that contained a lower-ratio "heavy" oil of about 16 deg API gravity.

The gas was separated from the oil and condensate in two stages, the first 1200 psig and the second at 500 psig. The gas was then processed by a natural gasoline plant. As the production from

A new heavy-duty gas-engine driven rotary rig will be used by the Lee Brown Drilling Company to drill more than 12,000 ft to the Ellenburger producing zone at the Plymouth Oil Company's J. B. Wallace No. 1, a north offset to the discovery well.





Slick-Urschel's Alford No. 1, discovery well of the Benedum field in Upton County, Texas, is producing through a temporary flow line (toward lower right) to a heater and high-pressure separator (not shown). The separated well fluid is then returned to the low-pressure flow-line from the well to the low-pressure separator (above). Plymouth's J. B. Wallace No. 1, north offset, is visible in the distance.

the Ellenburger reservoir declined rapidly from an annual peak of 6,580,000 bbl in 1931, water began to encroach on the southeast flank of the field. This was usually reflected by a sharp decrease in production of both oil and gas and the production of the darker 46 deg API gravity oil.

As stated, Benedum may not prove to be comparable to Big Lake in many respects, but it is perhaps well to ponder Big Lake field's history until more is known of the new field. The ultimate recovery of the mixture of oil and condensate produced at Big Lake is estimated to be about 1,000,000 bbl per well, or 20,000 bbl per acre, assuming the 25 wells drain the 1300 proved acres, or 50 acres per well. Then, without the benefit of core analysis data, we might conclude that the ultimate recovery per gross acre-ft of Ellenburger formation (using a thickness of 650 ft), will be about 31 bbl of liquid hydrocarbons. Now, applying this factor to, says, 975 ft of Ellenburger at Benedum, we might expect a recovery of 30,000 bbl per acre, or 2,400,000 bbl of crude oil and condensate (largely the latter) per well on a spacing pattern of 80 acres, and finally, without the benefit of seismic maps or other specific data on the probable extent of the new field, it would seem quite safe at this time to say that the new field will probably cover at least 1700 acres and produce 50,000,000 bbl or more. Much more optimistic "guesstimates" are rife, and this bit of comparison may soon seem oddly pessimistic, for many new wells are scheduled to be drilled in the general area of the discovery, due to expiring leases and the "boom" fever that has struck this part of West Texas.

A large quantity of casing and much heavy equipment will be required to develop the field. As much as 300 ft of 16-in., 60-lb surface pipe may be required to protect fresh water sands; 4000-ft intermediate string of 10¾-in., 32.75 to 45.5-lb casing may be needed to set through the salt section, and a 12,000-ft oil string of 5½-in., 17 to 20-lb, N-80 will be needed for each well. All christmas trees and fittings having a working pressure rating of 6000 psig and a test pressure of 10,000 psig will probably be required. A 12,000-ft string of 2-in. tubing; high pressure line pipe or tubing for flow lines; a gas heater; a 1000-psig separator, and a regular 125-psig separator; and four 500-bbl or 1000-bbl tanks will probably be needed for each Ellenburger well.

Heavy gas-engine or steam rigs, new strings of 4½-in. drill pipe, portable steel circulation pits, big new derricks, and tons of drilling bits and other equipment are being trucked toward the new area in increasing quantity. One 290-ft water well produced enough fresh water to supply all drilling requirements on the discovery well, which was drilled by Iron Drilling Company of Tulsa under the direct supervision of Jim M. Hewgley, a partner in the operation with Slick-Urschel. Sam W. Hogan served as petroleum engineer for the operators of the well.

This discovery well was granted a temporary allowable of 500 bbl a day, and the operators have been running a number of productivity index tests to find the most efficient rates of flow with various choke arrangements and separator pressures.

One of the early pressure tests when the well was shut in for 96 hr showed the following results: Casing pressure, 2600 psig; tubing pressure, 2679 psig; top of well fluid, at the surface; average pressure gradient from the surface to 10,000 ft, 0.20 lb per ft; average pressure gradient from 10,000 to 12,000 ft, 0.298 lb per ft; and corrected reservoir pressure at 12,000 ft, 5225 psig.

One of the productivity index tests at the rate of 20 bbl oil per hr and a gas-oil ratio of about 4400 cu ft per bbl yielded a P.I. of 2.11, i.e., the production of 2.11 bbl per day per lb reservoir pressure drop. Another such test at the rate of 37 bbl oil per hr and a ratio of 4000 cu ft per bbl yielded a P.I. of 1.27.

When the writer visited the well last month, it was flowing with a tubing pressure of 1800 psig through temporary flow lines to a heater where production was passed through a ½-in. choke and delivered at a pressure of 700 psig to a 2½ by 13-ft, 1000-psig separator. The gas from this first-stage separator was returned to the heater and delivered to a high-pressure manifold at about 690 psig for distribution to new drilling wells in the area. The excess gas was being flared. The oil and dissolved gas from the high-pressure separator was flowed back to a 3 by 13-ft, 125-psig second-stage separator being operated at 40 psig. The oil from this separator was being produced into a battery of five welded tanks.

Shell Pipe Line Company has laid about 10 miles of 8-in. line to the area and is running the oil from the discovery well.

Reference:

U.S. B.M., R.I. 3316, November, 1936, pages 150-183.

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Hydrocarbon absorption and fractionation process design methods

Part 11. Binary Distillation Calculations

By Wayne C. EDMISTER,
Hydrocarbon Research, Inc.
New York, N. Y.

EXCLUSIVE THE two-component fractional distillation calculations may be made by analytical or graphical methods, some of which are listed below:

- Analytical
  - Plate-to-plate calculations
  - Overall equations
- Graphical
  - x-y diagram
  - Enthalpy-composition diagrams

Both analytical calculation methods may be made with equilibrium constants or with relative volatilities. Also the equilibrium line for both the graphical methods may be constructed from relative volatilities or equilibrium constants. When constant relative volatility may be used, the equilibrium part of these design methods is greatly simplified.

In this chapter, a binary distillation problem will be computed by the plate-to-plate, x-y diagram, and H-X diagram methods. The mixture and conditions selected for this example illustrate the general case where α is not constant. The overall equation methods are based on constant α and so are not applicable to this problem.

If α, the relative volatility or the ratio of the equilibrium constants, is constant throughout the temperature range involved, then the equilibrium curve follows those in Fig. 40. Although this constancy is closely approached in actual practice, α does vary from one end of the fractionator to the other. For any two hydrocarbons the relative volatility is higher at low temperatures than at higher temperatures. Also the relative volatility is higher at low pressures than at higher pressures. In any one fractionator pressure does not change appreciably but temperature increases from top to the bottom.

The effect of pressure on the relative volatility often influences the selection of fractionation conditions. For example, K and α values are given in Table 51 for ethane and propane at two pressures, 100 and 170 psia, and at temperatures between the boiling points.

The K values in Table 51 are ideal fugacity equilibrium phase distribution constants, i.e. allowances for deviations from ideal gas laws but assuming ideal solutions. Separation of ethane and propane by fractional distillation would require more equilibrium stages at 170 than 100 psia but the lower pressure requires lower temperatures and more refrigeration.

At either pressure, the equilibrium line is higher at lower temperatures than at high temperatures. Also the equilibrium curves for the ethane-propane at these two pressures do not follow constant α curves, such as those shown on Fig. 40. Instead, the equilibrium curve is flatter at the lower end and has a slight bulge at the upper end. Fig. 40 may be used, if desired, in constructing an equilibrium curve or equation (82) may be used. In either case K constants or α values are required in the construction of the XY diagram.

When α is constant, or nearly so, points for the construction of the equilibrium line may be found from equation (82) with no regard for temperature. When α varies, as it does for the cases shown in Table 51, the effect of temperature on α must be taken into consideration.

ILLUSTRATION OF McCABE-THIELE GRAPHICAL METHOD

The McCabe-Thiele graphical method will be illustrated by an example in which the problem is to separate ethane and propane. Because of the low critical temperature of ethane, it is necessary to operate at a low pressure to obtain the desired separation. The boiling point of propane at 170 psia corresponds to the critical temperature of ethane so 170 psia is the highest practical pressure. Refrigeration is required to obtain the low top temperature for this pressure.

Fig. 43 is a plot of the K constants and the relative volatilities of ethane and propane at 170 psia between the boiling points of the two components. Relative volatilities are referred to propane. Note that the α value for ethane decreases with temperature.

Fig. 44 is a temperature-composition diagram for the ethane-propane system at 170 psia. This diagram is included for reference only. It cannot be used directly in making fractionation calculations.

TABLE 51. Effects of pressure and temperature on relative volatility of ethane-propane.

Pressure, psia	Temperature, F	Ethane K values	Propane K values	α = K ethane / K propane
100	−45	1.00	0.170	5.90
100	−10	1.67	0.355	4.70
100	+20	2.43	0.62	3.92
100	+52	3.35	1.00	3.35
170	−15	1.0	0.215	4.65
170	+20	1.53	0.410	3.74
170	60	2.25	0.720	3.13
170	90	2.90	1.0	2.90

TABLE 52. Component material balance for Example 24.

	Feed, Mols/hr	Distillate: Mols/hr	Distillate: Mol. fraction	Bottoms: Mols/hr	Bottoms: Mol. fraction
Ethane	33	30.3	0.97	2.7	0.04
Propane	67	0.9	0.03	66.1	0.96
Total	100	31.2	1.00	68.8	1.00

Example 24. Find the number of theoretical equilibrium plates required at different reflux ratios to separate ethane and propane from a feed containing 33 per cent ethane and 67 per cent propane. The distillate contamination is to be 3 per cent propane and bottom product contamination to be 4 per cent ethane. A tower pressure of 170 psi and refrigerated reflux will be used. The volatility data given in Table 51 may be used. The McCabe-Thiele graphical XY diagram method will be used first in the solution of this problem. Later, the Ponchon-Savarit method and then plate-to-plate calculations will be used for the same problem.

A component material balance is made on the operation. For two components this can be done directly by simple simultaneous equations but for multicomponent systems this material balance requires trial and error calculations, the final trial depending upon the results of the fractionation calculation. Table 52 gives the component distribution that satisfies the statement of the problem.

In using the α data in Table 51 for constructing an equilibrium curve, a curve showing the variations of α with x or y is necessary. This would not be necessary if one average value of α could be used but this is not possible in the case at hand. Fig. 45 is prepared from the data given in Table 51 by finding the value of x and y for ethane and propane at both the intermediate points and then plotting α vs. x. These values of x and y are found by direct calculations for binary systems. The results follow:

Compositions at 20 F and 170 psia.

	K	x	y
Ethane	1.53	0.527	0.807
Propane	0.41	0.473	0.193
		1.000	1.000

Compositions at 60 F and 170 psia.

	K	x	y
Ethane	2.25	0.183	0.41
Propane	0.72	0.817	0.59
		1.000	1.00

These data are used in preparing Fig. 45. From Fig. 45, α values are obtained and used to construct the equilibrium curve of Fig. 46. The points for the equi-

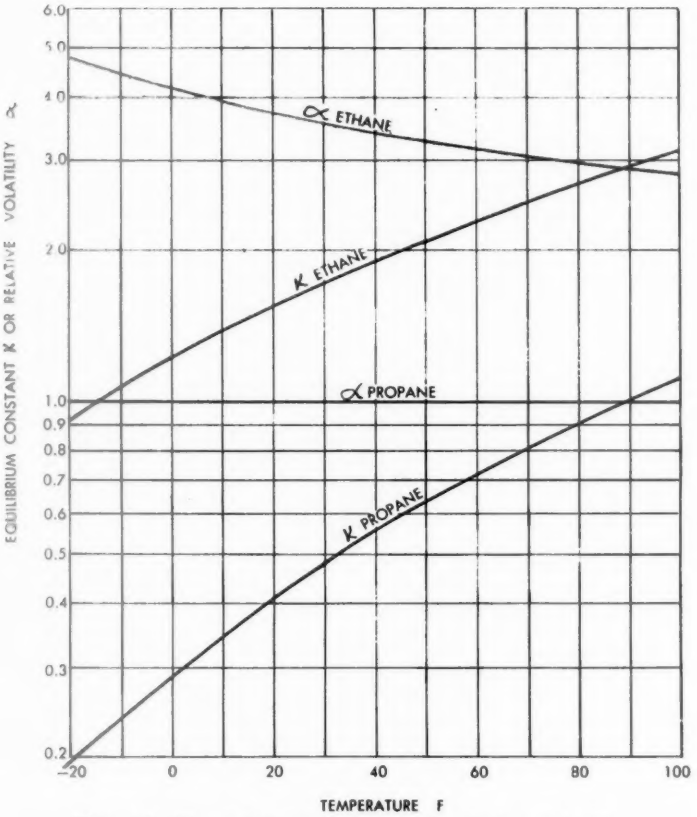


FIG. 43. Plot of K constants and relative volatilities of ethane and propane system at 170 psia.

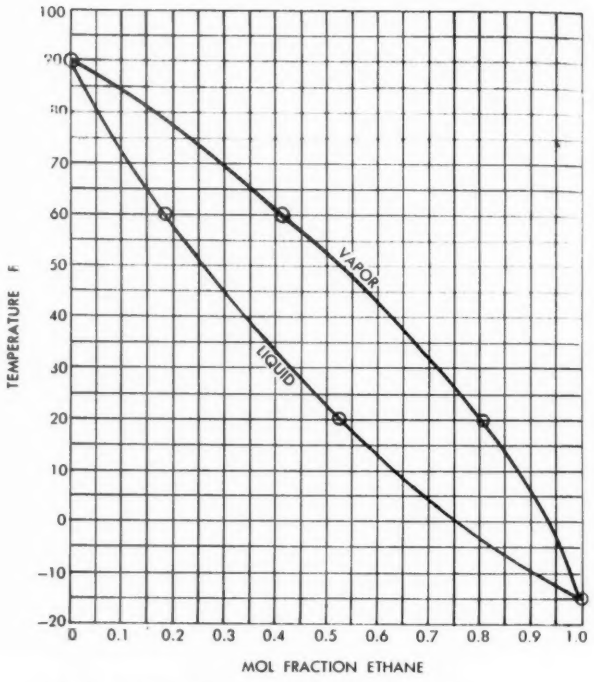


FIG. 44. Temperature-composition diagram for ethane-propane system at 170 psia.

librium curve are obtained as follows:

x Assumed	α Fig. 45	y Equation (82)
0.1	3.63	0.252
0.2	3.15	0.441
0.3	3.30	0.586
0.4	3.48	0.698
0.5	3.68	0.785
0.6	3.88	0.850
0.7	4.10	0.905
0.8	4.30	0.945
0.9	4.50	0.976

If an average α of 3.70 were used, the resulting terminal y values would be 0.29 and 0.971 as compared with 0.252 and 0.976.

Some of the charts included in this construction of the equilibrium line are extra for purpose of illustrating the principles.

With an equilibrium line thus determined, the operating lines were constructed to give an even number of theoretical plates (eight) for the desired separation. This graphical calculation is shown on Fig. 46.

The reflux ratio for this case is found from the slope of the enriching section operating line, for which the y intercept at x = 0 is 0.24 and the distillate composition is 97 per cent ethane.

$$\left(\frac{L}{V}\right)_{\text{enriching}} = \frac{(0.97 - 0.24)}{0.97} = 0.753$$

From this $\frac{L}{V}$ ratio the reflux to distillate ratio is found as:

$$\frac{L}{D} = \frac{\left(\frac{L}{V}\right)}{\left(1 - \frac{L}{V}\right)} = \frac{0.753}{(1 - 0.753)} = 3.05$$

Using this same equilibrium line, several other graphical solutions were made with different operating lines to find the number of theoretical plates required at other reflux ratios, including minimum and total reflux. Fig. 47 is a plot of the number of theoretical plates vs. the reflux ratio with the limits shown. The results of Fig. 46 solution are indicated.

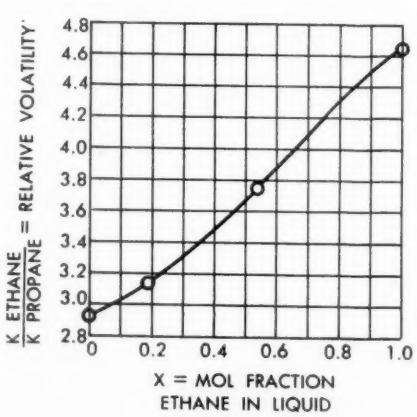
ENTHALPY-COMPOSITION DIAGRAM METHOD OF PONCHON-SAVARIT

For a binary system it is possible to construct an enthalpy-composition diagram for a given pressure. The two phase region of such diagrams may be used in making graphical fractional distillation computations. This type of analysis is known as the Ponchon-Savarit method and is particularly worthwhile for cases where constant overflow cannot be assumed. With constant overflow, it is more convenient to use the XY diagram method of McCabe and Thiele. The Ponchon-Savarit method is discussed briefly below because it, like the McGabe-Thiele method, represents a basic and fundamental concept that illustrates graphically the multistage fractional vaporization and condensation.

When the enthalpies of a binary mixture are plotted against the composition expressed as mol per cent of the lighter component, saturated vapor and liquid lines are obtained as boundaries of the two-phase region. These saturated lines are connected by equilibrium tie lines of constant temperature. Such a diagram forms the basis of the Ponchon-Savarit method as illustrated on Fig. 48. The end points of these equilibrium tie lines have as coordinates the compositions and enthalpies of the equilibrium vapor and liquid.

For ideal solutions the enthalpies of two components are additive and the heat of mixing is zero. Ideal solutions more often apply for vapor mixtures than for liquids. When ideal solution fugacity K constants may be used, heat of mixing may be neglected. Even in this case, the enthalpy versus composition lines for saturated liquid and vapor are curved because of the temperature-composition relationship, which is never straight. There are two reasons for this: (a) the temperature-composition curves are not even straight for ideal solutions, and (b) the

FIG. 45. Relative volatility vs. mol fraction ethane in liquid for ethane-propane system at 170 psia (Used in constructing equilibrium line in Fig. 46 for Example 24).



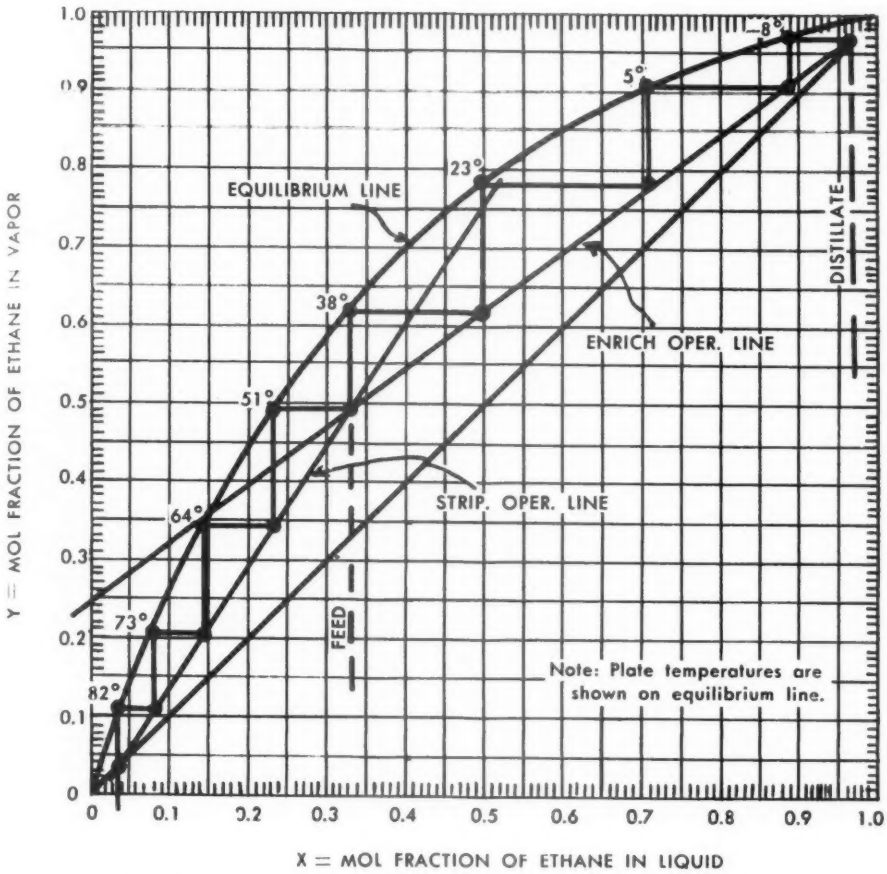


FIG. 46. Graphical solution of ethane-propane fractional distillation problem by McCabe-Thiele XY diagram method.

temperature—enthalpy relationships for saturated liquids and vapor are not straight either.

By drawing heat balance operating lines on this enthalpy-composition diagram, graphical steps may be made from one end of the distillation column to the other. The heat balance operating lines may be drawn from the known or assumed quantities of heat in the feed and the products plus the amounts added and removed via the reboiler and condenser. The slope of the equilibrium tie lines, the product and feed compositions plus the number of theoretical plates determine the location of the heat balance lines, although trial and error may be necessary to find them from these given data. After the operating line focal points are established, it is a simple matter to draw the remaining heat balance lines.

The points A and C, which are the operating line focal points for finite reflux, have coordinates that bear significant relationships to the distillation operation. The coordinates of point A are the composition of the bottoms product and the enthalpy of the net liquid downflow in the stripping section of the column. This enthalpy is equal to the enthalpy of the bottoms product minus the heat added in the reboiler, per unit of bottoms. The coordinates of point C are the composition of the distillate product and the enthalpy of the net vapor upflow in the enriching section of the column. This enthalpy is equal to the enthalpy of the distillate product plus the heat removed from the reflux condenser, per unit of distillate. The feed composition and enthalpy fall on a straight line connecting the two focal points, as shown by the points A, C, and F. If the enthalpy (and phase condition) of the feed and the heat quantities added in the reboiler and removed from the condenser are so adjusted, the point F will lie on a straight line connecting points B and D. On Fig. 48 this feed point F is shown on a straight line between B and D for both reflux cases. That is not always the case, however. It is of interest to point out that conditions resulting in B, D, and F being on a straight line, represent a most efficient utilization of heat, however. (See Benedict, "Multistage Separation Processes," Trans Am Inst Chem Engrs, *43*, 41 (1947))

At minimum reflux, the heat balance operating line focal points are closer to the saturated boundary curves, as shown by points A′ and C′. The feed point operating line, connecting points A′ and C′ for minimum reflux, coincides with the equilibrium tie-line in this part of the diagram (and column). A stepwise solution for the minimum reflux conditions will give infinite plates. For total reflux the focal points A′ and C are at minus and plus infinity, making the heat balance operating lines vertical. This, of course, results in the minimum number of trays.

Stepwise computations on the enthalpy-composition diagram, thus prepared, is a simple procedure similar to the application of the McCabe-Thiele XY diagram. It involves going from one end of the column to the other via the equilibrium and heat balance lines alternately, as illustrated by the following example.

Example 25. Solve example 24 by the Ponchon-Savarit enthalpy concentration graphical method.

The enthalpy-composition diagram is prepared by: (a) estimating the bubble and dew points at several compositions, and (b) computing enthalpies at these points.

Enthalpies at four points on the saturated liquid and saturated vapor lines are computed in Table 53 by assuming that the enthalpies are additive (no heat of mixing). The saturated liquid and vapor lines in Fig. 49 were plotted from these data.

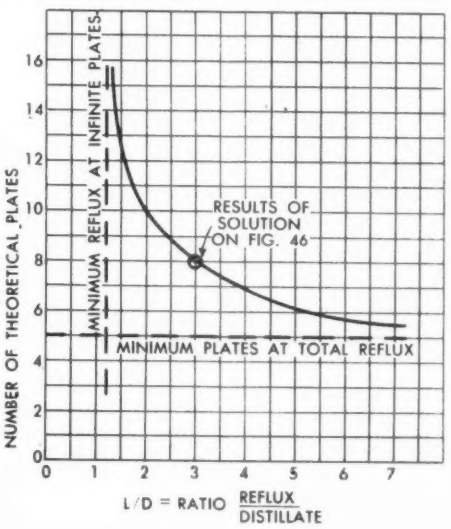
Equilibrium-tie lines were drawn from the x-y relationship given in Fig. 44. Operating lines were drawn through the focal points found from the amount of heat removed in the condenser and the feed composition and phase condition.

The heat to condense the distillate is 500 Btu/lb mol, and the reflux ratio was found to be 3.05 in Example 24. The heat removed in condensing reflux is $500 \times 3.05 = 1525$ Btu/lb mol of distillate, which locates the focal point of the enriching section operating lines. A straight line through this point "C" and the feed point "F" locates the focal point "A" for the stripping section operating lines. The graphical steps are then constructed.

This enthalpy-composition diagram solution confirms the XY diagram solution. It is of interest to point out that non-ideal solutions with an appreciable heat of mixing will have different results by the Ponchon-Savarit method unless the McCabe-Thiele operating lines are drawn to reflect the heat of mixing effects.

Under the conditions prevailing in this problem, the points B, F and D are not in a straight line. The temperatures indicated on the equilibrium tie-lines are the plate temperatures.

FIG. 47. Effect of reflux ratio on the number of theoretical plates for ethane-propane separation by fractionation.


MINIMUM REFLUX AT INFINITE PLATES
RESULTS OF SOLUTION ON FIG. 46
MINIMUM PLATES AT TOTAL REFLUX
NUMBER OF THEORETICAL PLATES
L/D = RATIO REFLUX / DISTILLATE

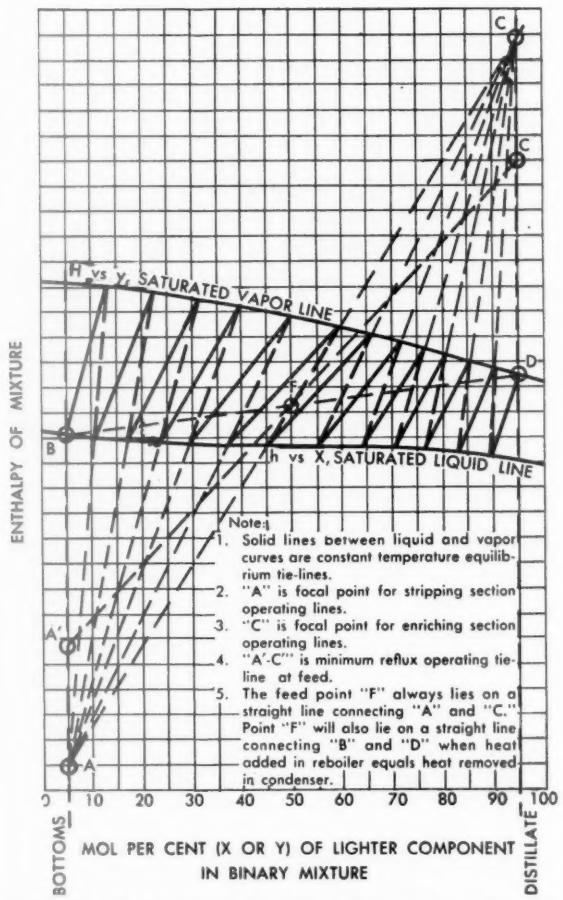

ENTHALPY OF MIXTURE
H vs Y, SATURATED VAPOR LINE
h vs X, SATURATED LIQUID LINE
Note:
1. Solid lines between liquid and vapor curves are constant temperature equilibrium tie-lines.
2. "A" is focal point for stripping section operating lines.
3. "C" is focal point for enriching section operating lines.
4. "A'-C'" is minimum reflux operating tie-line at feed.
5. The feed point "F" always lies on a straight line connecting "A" and "C." Point "F" will also lie on a straight line connecting "B" and "D" when heat added in reboiler equals heat removed in condenser.
BOTTOMS
DISTILLATE
MOL PER CENT (X OR Y) OF LIGHTER COMPONENT IN BINARY MIXTURE

FIG. 48. Enthalpy-composition diagram for binary mixture illustrating Ponchon-Savarit graphical fractionation calculation method using equilibrium and heat balance steps.

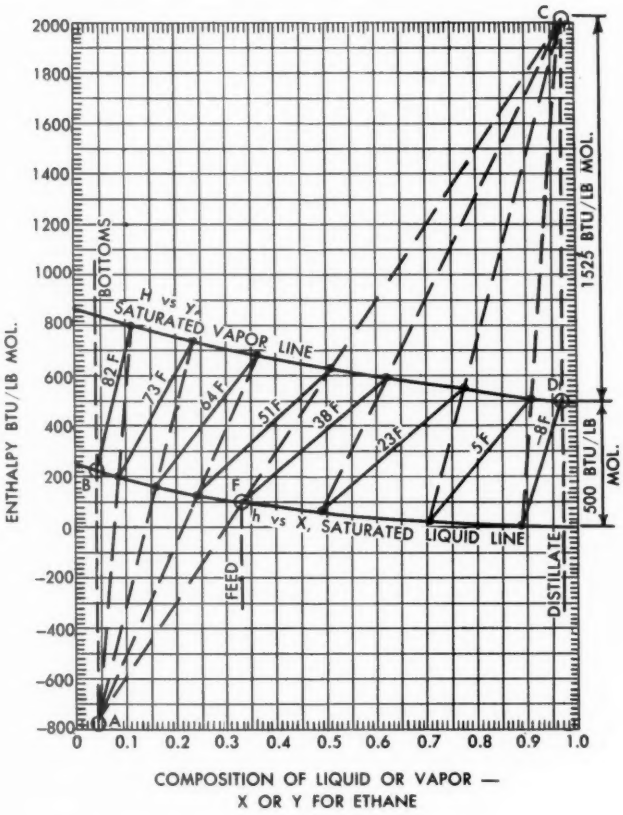


FIG. 49. Graphical solution of ethane-propane fractional distillation problem by Ponchon-Savarit enthalpy-concentration diagram method.

PLATE-TO-PLATE CALCULATIONS

As pointed out in the previous installment, plate-to-plate calculations are made by combining component material balances with equilibrium bubble or dew point determinations at each plate. For the material balance calculations, it is necessary to have the quantities of vapor and liquid flowing from plate to plate. For the bubble and dew point calculations, equilibrium constants or relative volatilities are required. Separation calculations could be made with α values for one component relative to the other without knowing the actual K values of either. This would not permit the computation of any temperatures.

To check temperatures, K values are required. It is most convenient to make the plate-to-plate computations with α values and then estimate K values and check temperatures at any desired point later. This is done by finding the K values from equation 83 of Part 10, and the values of α and x on the plate in question and then finding the corresponding temperature from a K plot, such as Fig. 43.

These plate-to-plate calculations are started at both the condenser and the reboiler with the known, or assumed, product compositions and continued step-by-step until it is clear that the compositions overlap. Then the enriching and stripping section calculations are meshed and the number of plates in each section determined.

The enriching section plate-to-plate calculations involve the following steps at each equilibrium stage.

Step 1: Starting with the liquid going to any stage, add the components of the distillate product, obtaining the vapor from the same tray.

Step 2: Divide the mols of each component in the vapor by α, its relative volatility.

Step 3: Find $\Sigma \frac{v}{\alpha}$ and compute the amount and composition of the liquid leaving the stage from

$$l = \frac{(v/\alpha)L}{\Sigma\,(v/\alpha)}$$

Step 4: Add to this liquid the components of the distillate to get the vapor

TABLE 53. Enthalpies (Btu/lb mol) for Example 25.

Temp. F	Component	Saturated liquids			Saturated vapors		
		x	h*	xh	y	H*	yH
−15	Ethane	1.0	0	0	1.00	490	490
	Propane	0	0	0	0	769	0
	Total	1.0			1.00		490
20	Ethane	0.527	64.5	34.0	0.807	490	396
	Propane	0.473	79.3	37.5	0.193	805	155
	Total	1.000		71.5	1.000		551
60	Ethane	0.183	156	28.6	0.41	466	191
	Propane	0.817	176	144.0	0.59	840	495
	Total	1.000		172.6	1.00		686
90	Ethane	0	358	0	0	358	0
	Propane	1.00	255	255	1.00	863	863
	Total	1.00		255	1.00		863

*h and H are enthalpies of saturated liquids and vapors, respectively, for the pure components in Btu lb mol, above saturated liquid at −15 F.

TABLE 54
Plate-to-plate calculations.
Fractionation of ethane-propane at 170 p.s.i.a.

Enriching Section

L/v = 0.753, D = 31.2 mols/hr, V = 126.3 mols/hr, L = 95.1 mols/hr

	Condenser				Plate 1				Plate 2				Plate 3				Plate 4			
	d	α	d/α	l_d	v_1	α	v_1/α	l_1	v_2	α	v_2/α	l_2	v_3	α	v_3/α	l_3	v_4	α	v_4/α	l_4
C_2	30.3	4.4	6.88	84.1	114.4	4.1	27.9	66.7	97.0	3.7	26.2	44.9	75.2	3.4	22.1	28.7	59.0	3.3	17.9	20.0
C_3	0.9	1.0	0.9	11.0	11.9	1.0	11.9	28.4	29.3	1.0	29.3	50.2	51.1	1.0	51.1	66.4	67.3	1.0	67.3	75.1
Σ	31.2		7.78	95.1	126.3		39.8	95.1	126.3		55.5	95.1	126.3		73.2	95.1	126.3		85.2	95.1
			$l_d = \frac{(d/\alpha)L}{\Sigma(d/\alpha)}$		$v_1 = l_d + d$		$l_1 = \frac{(v_1/\alpha)L}{\Sigma(v_1/\alpha)}$		$v_2 = l_1 + d$		$l_2 = \frac{(v_2/\alpha)L}{\Sigma(v_2/\alpha)}$		$v_3 = l_2 + d$		$l_3 = \frac{(v_3/\alpha)L}{\Sigma(v_3/\alpha)}$		$v_4 = l_3 + d$		$l_4 = \frac{(v_4/\alpha)L}{\Sigma(v_4/\alpha)}$	

Stripping Section

V/L = 0.647, B = 68.8 mols/hr, V = 126.3 mols/hr, L = 195.1 mols/hr

	Reboiler				Plate 1′				Plate 2′				Plate 3′				Plate 4′			
	b	α	αb	v_b	$l_{1'}$	α	$\alpha l_{1'}$	$v_{1'}$	$l_{2'}$	α	$\alpha l_{2'}$	$v_{2'}$	$l_{3'}$	α	$\alpha l_{3'}$	$v_{3'}$	$l_{4'}$	α	$\alpha l_{4'}$	$v_{4'}$
C_2	2.7	2.9	7.8	13.3	16.0	3.0	48.0	26.7	29.4	3.1	91.2	44.9	47.6	3.2	152.2	64.2	66.9	3.3	221.0	80.0
C_3	66.1	1.0	66.1	113.0	179.1	1.0	179.1	99.6	165.7	1.0	165.7	81.4	147.5	1.0	147.5	62.1	128.2	1.0	128.2	46.3
Σ	68.8		73.9	126.3	195.1		227.1	126.3	195.1		256.9	126.3	195.1		299.7	126.3	195.1		349.2	126.3
			$v_b = \frac{(\alpha b)V}{\Sigma(\alpha b)}$		$l_{1'} = v_b + b$		$v_{1'} = \frac{(\alpha l_{1'})V}{\Sigma(\alpha l_{1'})}$		$l_{2'} = v_{1'} + b$		$v_{2'} = \frac{(\alpha l_{2'})V}{\Sigma(\alpha l_{2'})}$		$l_{3'} = v_{2'} + b$		$v_{3'} = \frac{(\alpha l_{3'})V}{\Sigma(\alpha l_{3'})}$		$l_{4'} = v_{3'} + b$		$v_{4'} = \frac{(\alpha l_{4'})V}{\Sigma(\alpha l_{4'})}$	

to the plate from the plate below. These same steps are repeated at each plate in the enriching section.

The stripping section plate-to-plate calculations involve the following steps at each equilibrium stage:

Step 1: Starting with the vapor going to any stage, add the components in the bottoms product, obtaining the liquid leaving the same plate.

Step 2: Multiply the mols of each component in the liquid by α, its relative volatility.

Step 3: Find $\Sigma(\alpha l)$ and compute the amount and composition of the vapor leaving the plate from

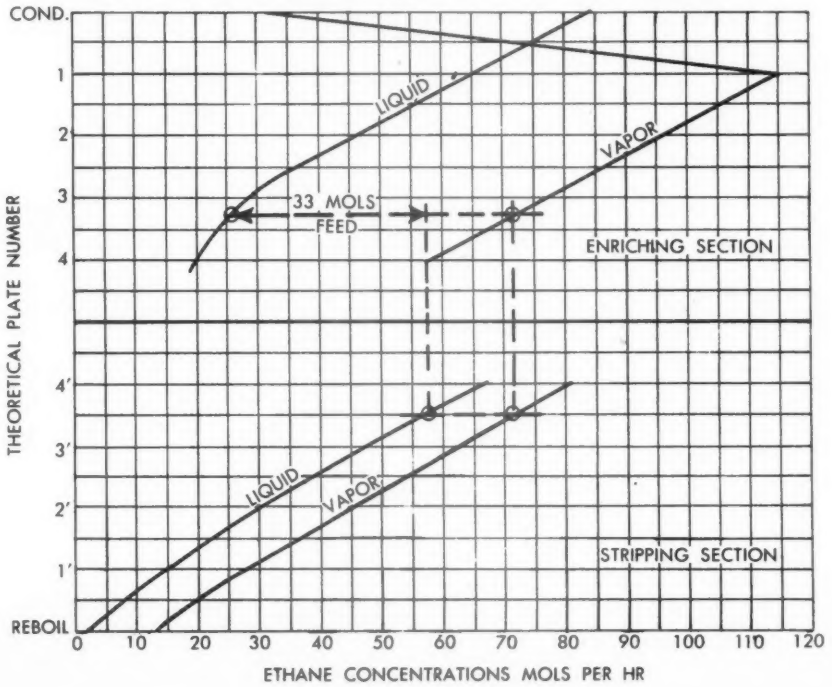
$$v = \frac{(\alpha l)V}{\Sigma(\alpha l)}$$

Step 4: Add this vapor to the component of the bottoms to get the liquid overflowing from the plate above.

These same steps are repeated at each plate in the enriching section.

Example 26: Solve the above ethane-propane separation problem by the plate-to-plate method using α values obtained from Fig. 43.

FIG. 50. Plot of ethane concentrations in vapor and liquids in enriching and stripping calculations in Table 54, showing ing feed plate mesh of liquid and vapor concentrations.



Selecting α values for this calculation requires some judgment but it does not involve as much trial and error as using K constants directly would.

The solution of this example is given in Table 54, where the calculations were started at each end with the desired product compositions from Table 51. These calculations were made for four theoretical plates in each section in addition to the condenser and reboiler.

It is clear from the results that the liquid and vapor compositions shown in Table 54 overlap but do not mesh. The most convenient way to mesh these results at the feed plate is shown in Fig. 50 where the ethane concentrations are plotted vs. plate number,

The concentration of ethane liquid to the enriching section at the feed plate is 33 mols less than the amount of ethane in the liquid leaving the feed plate. On the other hand, the concentrations of ethane in the two vapors must be equal. This determines one and only one mesh point.

The results of the plate-to-plate calculations give 3.3 enriching plates and 3.5 stripping plates. To each of these must be added the condenser and reboiler to get the total of (3.3+1.0)+(3.5+1) = 8.8 total theoretical stages as compared with a total of eight by the two graphical methods. The explanation of this difference is that the graphical constructions cannot be made as precise as analytical calculations. This is particularly important when there are many small graphical steps.

The analytical method shown can be applied to three or more components with equal ease where product compositions are accurately known. Where this is not the case, several trials are necessary to balance the compositions.

In the next installment, the study of fractionation fundamentals will be extended to multicomponent mixtures.

(Part 12 will be published soon.)

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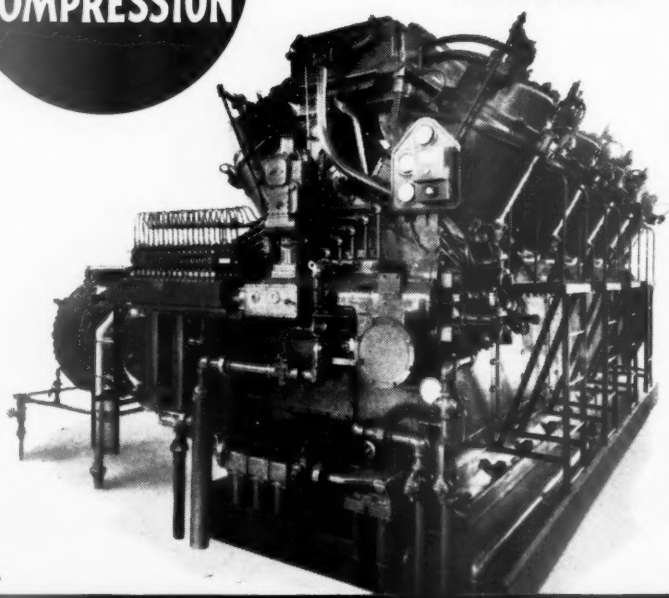

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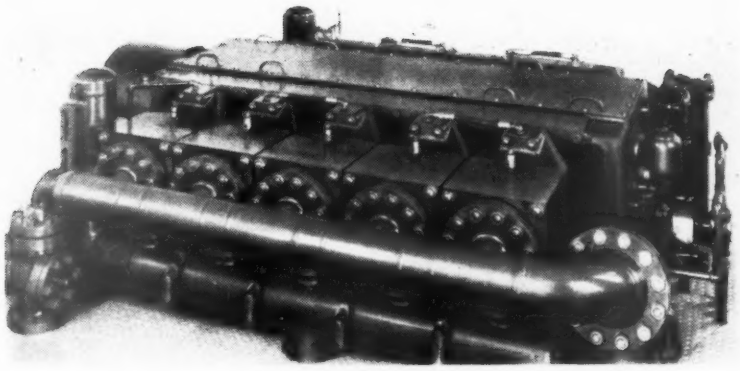

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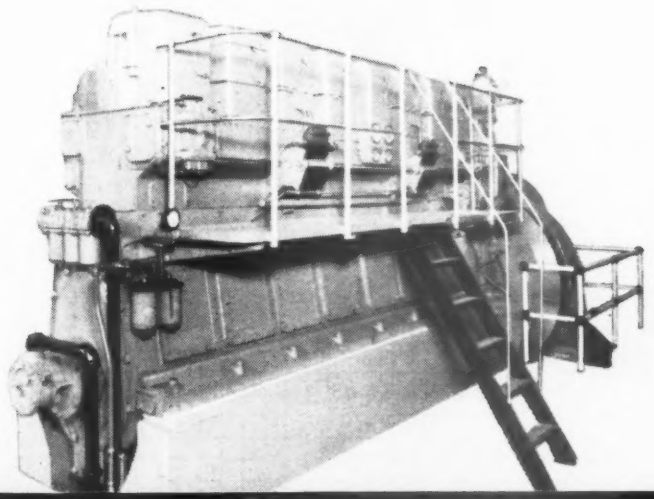

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Diamond coring of chert, limestone, and dolomite of West Texas Permian Basin

By ARTHUR W. McCRAY, The Atlantic Refining Company

● **Introduction.** In the summer of 1947, three wells were diamond cored by The Atlantic Refining Company in the University Block 31 field, Crane County, Texas. The sections cored were in the chert, limestone, and dolomite rocks of West Texas. The wells were designated as the Z-1, W-1, and X-1; and they were cored in that order. In the Z-1, both the upper and lower zones were cored in the Devonian. The upper zone consists of massive chert and chert interspersed in limestone; the lower zone is chiefly limestone. In the W-1, a section of the Ellenberger was cored that was crystalline dolomite with some vuggy sections; and in the X-1, the Lower Devonian was cored. With the exception of the Upper Devonian zone of the Z-1, the diamond coring was carried out through holes in which casing had been set above the formation to be cored.

EXCLUSIVE

Additional drilling rig work was involved in only a portion of the coring. It had been planned to core the Upper Devonian of the Z-1 with 6⅛-in. hole and ream the 75-ft cored section with regular rock bits to 8¾ in. During the coring of the X-1, additional rig work occurred in the reaming of 200 ft of cored hole after the core barrel once became stuck. Otherwise, no great amount of additional drilling rig expense was involved because of the coring; the drilling time rates of the various wells throughout the field have varied enough so that one cannot exactly tell how long it would take to drill the wells by regular drilling practice. Coring rates were comparable, although slightly lower, than the average of the offset wells, on the basis of actual feet of hole made per day. The coring was prompted by the desire for more accurate reservoir information, and diamond coring was the only known method of obtaining satisfactory cores from the friable or brittle limestones, dolomites, and cherts. The success attained in making hole with the diamond bits used on the regular drill string leads to the speculation of what might be accomplished if the drill strings were properly modified to suit the diamond bit.

The following discussion describes various phases of running the diamond core bits. It has been found that rates of penetration are very sensitive to the nature of the rock being drilled, and correlations between penetration rates and electric logs have been observed. Recognition of this fact prevented the making of many needless round trips when the rate of penetration of the bit became quite slow. An attempt has been made to separate the factors that affect penetration rates from those that do not, in order that some basis may be had for design of equipment that will ultimately increase rates of penetration of diamond bits in the deep wells in the limestone areas.

● **Technique of running the diamond core barrel.** *Drill strings.* Table 5 gives the drill strings used in the wells that were diamond cored. The general rule was to use enough drill collars to supply the weight run on the diamond bit; the drill collars and drill pipe had to be of small enough size to follow the core barrel down into the cored hole, except where reaming immediately followed the coring as in the Upper Devonian of the Z-1. In coring the X-1, only one stand of drill collars was used; and although this was less than the weight generally carried on the bit, no particular difference could be detected in the performance of the diamond bits.

Starting the bit. The success attained in the diamond coring during the summer of 1947 may be attributed to many factors. The drillers and tool pushers displayed the understanding and patience necessary to the running of the diamond bits. The drilling engineers involved had excellent understanding of the technique as shown by the results. Of all phases of the technique used, that which made the most for successful operation was the proper starting of the diamond bits.

The hole in which a diamond bit is to be run should be as clean and free from fragments of steel such as rock bit teeth and rock chips as it is possible to leave it with rock bit and basket. Probably in no case will the hole be entirely clean; it isn't practical to make it so. When the diamond bit follows a rock bit, it should be borne in mind that the diamond bit will not fit the bottom of the hole left by the rock bit, and a "seating in" process must take place. The method of starting the diamond bit must take into account that chips of metal or hard rock are lying on the bottom of the hole, and, if these lodge and roll under the bit they will tear up the matrix supporting the diamonds; and it must also take into account the possibility that the bit does not fit the bottom of the hole.

When first beginning to drill with a diamond bit, the bottom of the hole may be felt lightly without rotating the bit, or other measurements may be used, so that the diamond bit may be held a few inches above bottom. Drilling mud flow is then used to wash the bottom of the hole clean of loose fragments of rock or steel. These chips pass up through the three "junk slots," which are about ½ in. wide and ¼ in. deep and placed in the outer circumference of the diamond bit. During this washing process, which may last from 10 to 30 min, the drill string may be held still, but it is preferably rotated slowly. The rate of mud flow should be set for coring. From 30 to 40 gpm were used with the 4¾-in. bits and 60 to 70 gpm with the 6⅛-in. bits. Then, after washing the bottom of

FIG. 1. Well Z-1, University Block 31, Upper Devonian formation.

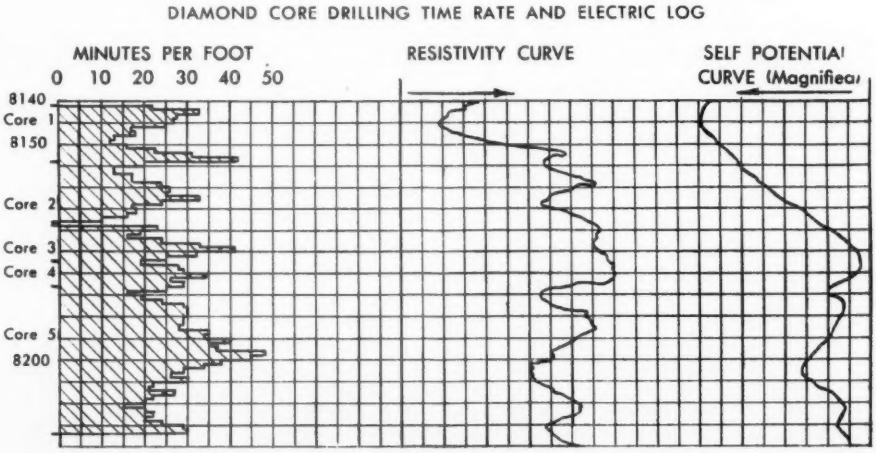

TABLE 1. Drilling time, minutes per foot, Upper Devonian, Well Z-1.

Core 1—8141-8154 ft
22-33-28-27-25-17-18-13-12-16-23-31-13

Core 2—8154-8168 ft
20-13-13-17-17-24-26-25-33-24-17-18-16-10

Core 3—8169-8177 ft
23-19-16-24-33-41-32-25

Core 4—8177-8183 ft
19-28-29-34-26-29

Core 5—8183-8216½ ft
25-16-19-24-29-30-30-29-29-28-35-34-40-35-37-48-45-38-34-29-26-30-22-21-27-22-20-15-20-22-20-24-29-15

Remarks: Eight feet of cavings were found between first and second runs, and 1 hr was required to wash down to bottom. Bottom was then washed for 40 min. At end of Core Run 4, pump pressures rose from 300 to 900 psi, and that and the failure of the bit to dig off in a few minutes' time was diagnosed as a worn out bit. When the bit was pulled, it looked about the same as when it went in (slightly bare on outer shoulders probably caused by wobbling during coring), but small pieces of chert were lodged in the water courses and these had presumably restricted circulation. A new bit was used for Run 5.

TABLE 2. Drilling time, minutes per foot, Lower Devonian, Well Z-1.

Core 6—8571-8588 ft
53-34-27-24-22-23-26-22-20-31-29-23-19-20-22-24-26

Core 7—8588-8614 ft
22-26-20-36-36-31-17-15-16-11-26-24-19-21-40-19-15-22-21-21-19-15-20-18-19

Core 8—8614-8639 ft
23-25-29-30-25-25-25-27-26-25-18-18-18-16-16-17-12-11-13-10-12-11-11-12-10

Core 9—8638-8654 ft
16-26-31-35-57-70-45-90-43-32-27-22-41-37-20-18

Core 10—8654-8678 ft
43-42-70-50-40-25-25-15-17-29-29-34-32-36-48-43-42-45-53-62-40-30-29-25

Core 11—8678-8703 ft
41-23-44-45-42-40-25-30-43-40-67-25-22-43-22-25-27-30-20-30-43-32-25-35-30

Core 12—8703-8727 ft
27-25-23-25-20-15-15-21-18-30-24-25-24-28-30-41-22-23-25-20-19-19-19-14

Core 13—8727-8751 ft
30-15-15-16-19-16-35-24-25-23-27-23-27-35-47-33-30-30-31-42-29-30-36-36

Core 14—8751-8700 ft
75-95-80-70-70-32-42-65-60-70-75-73-45-47-53-55-42-44-51

Core 15—8770-8794 ft
45-72-84-73-79-45-45-60-65-90-80-45-49-42-51-31-30-27-33-37-37-33-31-28

Core 16—8794-8834 ft
42-30-45-38-25-25-25-25-12-13-15-15-15-14-11-15-15-20-20-15-15-15-11-10-15-14-14-12-12-12-10-11-11-11-15-12-15-22-38-18

Core 17—8834-8874 ft
12-17-18-19-17-14-17-19-16-14-11-11-11-23-20-19-14-18-20-26-19-18-21-23-34-32-53-82-65-40-33-67-37-38-40-48-37-18-20-17

Core 18—8874-8907 ft
13-15-14-11-11-16-23-17-30-18-20-25-23-23-21-26-28-24-25-27-31-23-29-21-49-35-36-32-39-34-32-40-36

Core 19—8907-8927 ft
57-55-90-30-40-60-80-40-75-55-40-55-46-52-44-31-47-40-42-33

TABLE 3. Drilling time, minutes per foot, Lower Devonian, Well X-1.

Core 1—8599-8623 ft
19-21-15-16-18-20-19-19-22-21-18-16-14-16-18-19-17-19-20-18-19-18-27-19

Core 2—8624-8662 ft
50-28-26-25-21-20-17-13-15-15-15-15-16-19-16-15-15-16-15-15-15-16-17-16-19-23-20-30-45-45-30-23-20-26-24-30-60-90

Core 3—8662-8702 ft
30-33-29-26-22-26-29-26-26-21-21-23-20-20-17-18-16-19-20-23-19-23-21-25-20-27-25-28-22-27-28-33-44-60-38-45-29-63-60-65

Core 4—8702-8742 ft
25-35-78-17-20-24-27-25-20-17-23-22-20-17-20-20-17-21-21-25-24-28-30-40-30-17-30-24-26-27-43-49-45-28-27-22-24-22-21-28

Core 5—8742-8782 ft
20-21-19-13-16-14-15-17-19-24-20-18-18-17-17-19-17-21-23-18-18-22-19-17-20-17-12-17-16-16-16-15-17-20-21-17-20-10-10-16

Core 6—8782-8822 ft
28-22-30-40-41-28-27-16-19-19-18-23-19-17-19-20-21-15-18-19-17-19-16-15-17-17-17-23-18-19-25-25-21-18-17-18-18-24-20-21

Core 7—8824-8864 ft
30-36-36-26-24-26-27-27-25-28-32-30-30-30-30-45-30-34-29-24-27-29-31-32-34-37-48-40-56-52-34-60-46-41-55-52-48-58-47

Core 8—8864-8904 ft
45-40-30-27-21-25-21-23-16-15-16-15-16-12-11-13-12-14-14-20-17-17-21-18-18-17-17-39-34-34-30-30-28-30-32-28-16-19-45-30

Core 9—8904-8920 ft
30-23-16-19-19-18-16-14-13-14-16-18-16-17-17-20

TABLE 4. Drilling time, minutes per foot, Ellenberger, Well W-1.

Core 9—10,491-10,529 ft
15-17-15-17-17-17-16-14-14-17-17-18-20-24-19-22-19-22-22-24-22-27-42-38-39-66-74-24-22-31-19-20-21-18-13-20-19-20

Core 10—10,529-10,559 ft
16-24-31-28-25-30-25-23-23-17-21-22-55-25-48——20-17-23-15-20-25-20-25-40-25-29-23-23-26

Core 11—10,560-10,600 ft
27-47-25-25-25-30-24-30-26-20-15-28-42-23-14-13-16-16-16-14-15-16-12-14-21-17-16-14-15-18-21-21-19-17-16-29-30-35-35-35

Core 12—10,600-10,623 ft
38-48-41-34-25-31-32-28-25-28-23-28-24-28-25-20-20-35-20-25-15-15-75

Core 13—10,623-10,663 ft
30-26-13-23-19-20-18-21-12-13-15-14-15-12-14-14-15-19-20-19-17-16-12-15-16-18-12-11-14-19-20-12-11-10-12-18-13-17-23-22

Core 14—10,663-10,703 ft
16-19-19-22-22-24-22-23-25-30-25-20-20-22-20-20-23-20-20-17-23-23-22-27-25-28-23-18-16-17——26-18-20-28-24-25-30-26-25

the hole, the diamond bit is slowly lowered while rotating at the slow rate of 10 to 15 rpm. If the bit must "seat itself in," weight is kept down to about 500 lb until a small amount of hole has been made. When it is estimated that the diamond bit is drilling in a groove that fits the convex diamond matrix, the weight on the bit is increased up to the best weight determinable for the diamond drilling.

After picking up the core barrel off bottom during the core run, the same procedure should be used in re-starting the bit; i.e., washing the bottom of the hole, slow rotation, gradually lowering the bit and applying weight.

Weight on the bit. The weight actually held on the diamond bit against the bottom of the hole is a hard property to measure. It is ordinarily taken to be the difference between the reading of the weight indicator with the bit held off bottom and the reading while drilling. This is a simple enough definition, and would seem to give a definite answer; however, the weight indicators used are not constant in their readings. Another consideration is that the drill pipe may take up some of the apparent weight on the bit by its friction in rotating against the walls of the hole. There is the possibility that the true straightness of the hole may cause a difference in the proper apparent weight to hold on a bit. Still further consideration is the pressure of the drilling mud, which presses upward against the bottom of the bit, and this is not always constant. Thus, there are two measures: The apparent weight on the bit and the effective weight on the bit.

The greatest difficulty experienced with the weight indicators was their sensitivity to temperature changes. The coring operations were performed in the summer months, and, in the West Texas area, the difference in temperature between two o'clock in the afternoon and four o'clock in the morning is probably 60 F. In any event, it was enough to cause differences in reading of the weight indicator, with the bit raised off bottom, of 10,000 to 18,000 lb, with the highest reading being obtained when the temperature was highest. Most of the coring was done with weights on the bit from 5000 to 8000 lb. Thus, it may well be imagined that at the times of most rapid temperature change, which ordinarily are from about six to ten in the morning and from about five to eight in the evening, the drillers were hard pressed to out-guess the weight indicators. It was often necessary at such times to stop rotating and pick up the drill string in order to ascertain the weight off bottom so that the weight put on the bit could be determined. Probably about two hours per core could have been saved if an accurate weight indicator had been available.

The apparent weights used on the 6⅛-in. diamond bits in the Upper Devonian of the Z-1 varied from 6000 to 20,000 lb, and the greater weights were inadvertently used because of variations in the weight indicator. In the dense chert and lime chert being drilled, however, the high weights on the bit gave a good drilling rate. In the lower Devonian in the Z-1 and in the X-1, apparent weights on the 4¾-in. bits varied from 3000 to 8000 lb, with the usual weight being around 6000 lb, as nearly as could be determined. There were times when more apparent weight was used, but those were not representative conditions. In the Ellenberger of the W-1, satisfactory weights on the 4¾-in. bits were usually between 5000 and 8000 lb. In

TABLE 5. Drill strings.

	Z-1 Upper Devonian	Z-1 Lower Devonian	W-1 Ellenberger	X-1 Lower Devonian
Well drill pipe:				
O D	4½	2⅞	2⅞	3½
I D	4	2⅛	2⅛	3
Drill collars:				
Nominal size*	4½	2⅞	2⅞	2⅞
O D, in.	6¼	4¾	4¾	4¾
I. D, in.	2¼	1¼	1¼	1¼
Wt./ft, lb	90 7	42 2	42 2	42 2
Length, ft	180	150	120	90
Total wt., lb	16,300	6330	5060	3800
Indicated total weight, lb	132,000 to 154,000	88,000 to 97,000	115,000 (approx.)	130,000 (approx.)

*Based on data listed by manufacturer.

the crystalline dolomite, weights of 10,000 lb or more were excessive; drilling progress stopped at weights of about 10,000 lb on the bit.

Rotary speeds. If the supposition is made that the diamond bit drills exactly as a tool held in a lathe with each diamond gouging out a groove in the rock as the bit rotates, it follows directly that the greater the rate at which the diamond bit is rotated the greater will be the rate of penetration into the rock. Such is not found to be the case. It must be remembered that the diamond bit was fastened to the lower end of from 8000 to 10,000 ft of rotating pipe, and was not as solidly held against the material being cut as is the tool in the lathe. The drill pipe is free to wobble around in the hole, if it will, and longitudinal vibrations may thus be induced. It would also seem that the straightness, the slope, and the curvature of the hole would affect the action of the drill string.

During coring of the Upper Ellenberger in the W-1 in April of 1947, it was observed that breaks were made in the core that did not correspond to planes of weakness of the rock. Such breaks were obviously made by bit action. The broken core jammed in the inner core barrel. If such core breakage could be eliminated, longer core runs would be possible. With rotary speed reduced from over 100 to the range of 60 to 80 rpm, core runs of 40 ft became commonplace, and in many runs very little core breakage occurred. In this connection, it must also be mentioned that the proper starting of the bit, which results in the first part of the core entering the inner barrel without any jamming by fragments, is very important to the obtaining of a long core run. If from the start no excessive force is required to cause the core to follow up into the inner barrel as the drilling progresses, the chances of the core fracturing inside the inner barrel become less, and less lateral hunting of the diamond core bit will occur, which produces a wobbly cut core.

The arguments against using high rotary speed are: (1) The wobbling of the drill pipe in the hole at higher speeds may induce longitudinal strains in the drill pipe, which alternately increase and relieve the weight on the bit, if they do not actually lift the bit off the bottom for short time intervals; (2) unsteady bit action spalls out pieces of core being cut and breaks the core into many short pieces, which may jam in the inner core barrel and keep the bit from drilling ahead, and (3) excessive wobbling of the drill pipe in an uncased hole may knock cavings off the walls of the hole.

During the coring of the Z-1 and X-1 and the deepening of the W-1, the use of rotary speeds of 60 to 80 rpm was used almost throughout the operations. There are no known instances where it can be said that 60 rpm were better than 80, or vice versa.

Core Run No. 15 can be compared to No. 14 in Well Z-1. Finely crystalline limestone was drilled in both. In No. 14, a rotary speed of 80 rpm was used; in No. 15, a speed of 60 was used. The same range of drilling rates appears in both, except the last part of No. 15, which was beginning to pass into softer strata. The rates seem to compare with those obtained in the first diamond coring in the W-1 in April when speeds of 120 rpm were used. If there does actually exist a difference in drilling rates because of differences in rotary speeds in those ranges, with the drill strings used, it is small in comparison to the large differences in rates caused by variation in the rock texture.

Drilling fluid circulation and properties. Water base, oil emulsion, and oil base drilling fluids were used in the diamond coring, and no particular advantage can be claimed for any one of them as far as the working of the diamond bit and core barrel is concerned. Oil emulsion was used in the Upper and Lower Devonian of the Z-1, and for the coring of the W-1, and oil base was used for the lower Devonian of the X-1, with the exception that water base was used for the first core (before setting casing) in the X-1, and water base was used in the first coring program of the W-1.

An advantage has sometimes been claimed by some operators for muds containing oil, in that they lubricate the bearings of the diamond core barrel and help prevent bearing failure. Most coring in Block 31 has been done with oil emulsion mud; no trouble was experienced with bearings, although they were finally renewed during the final coring of the X-1. The later improvements of core barrels include the sealing of the bearings (which support the inner core barrel) with lubricant sealed in. Of course, a main advantage of this is that it prevents bearing parts, such as ball bearings, from being washed down under the diamond bit and ruining the bit.

The muds used varied in viscosity

TABLE 6. Coring Upper Devonian, Well Z-1, Block 31.

Core no.	Bit no.	From	To	Ft	Recovery, ft	Time OB	Avg. min./ft	Weight on bit, lb.	Rotary rpm	Pump press.,psi	Gpm
1	WR459	8141	8154	13	12.8	4:38	21.4	8,000- 9,000	57-65	250-475	60-70
2	WR459	8154	8168	14	14.0	4:33	19.5	9,000-20,000	67	75-150	60-70
3	WR459	8169	8177	8	7.7	3:33	27.7	6,000-10,000	68	250-350	60-70
4	WR459	8177	8183	6	5.5	2:50	28.3	4,000-16,000	68-86	225-300	50-80
5	WR460	8183	8217	33	33.3	16:10	29.4	10,000-19,000	69-70	200-300	50-80
				74	73.3	31:44	25.7 avg.				

TABLE 7. Coring Lower Devonian, Well Z-1, Block 31.

Core no.	Bit no.	From	To	Ft	Recovery, ft	Time OB	Avg. min. ft	Weight on bit, lb.	Rotary rpm	Pump press.,psi	Gpm
6	WR310	8571	8588	17	17.2	7:25	26.2	3000	78-95	250-400	35-45
7	WR310	8588	8614	26	25.1	9:33	22.0	3000	74-78	225-350	35-45
8	WR310	8614	8639	25	25.0	7:45	18.6	3000-4000	75-80	350-450	35-45
9	WR310	8639	8654	15	15.0	9:50	38.1				35-45
10	WR310	8654	8678	24	24.2	15:24	38.5				35-45
11	WR310	8678	8703	25	24.9	14:36	35.0		80	250-375	35-45
12	WR310	8703	8727	24	24.0	9:27	23.6		80	250-375	35-45
13	WG311	8727	8751	24	24.0	11:19	28.3	5000 to 7000	80	250-375	35-45
14	WR310	8751	8770	19	19.0	19:29	61.5		80	250-375	35-45
15	WR310	8770	8794	24	23.4	20:47	52.0		60	275-400	35-45
16	WG311	8794	8834	40	41.7	12:33	18.8		80	250-375	35-45
17	WG311	8834	8874	40	39.7	18:06	27.2		80	250-350	35-45
18	WR497	8874	8907	33	33.0	14:37	26.6	6000	80	250-375	35-45
19	WR497	8907	8927*	20	20.0	17:12	51.6	6000	80	250-450	35-45
				356		188:03	31.7 avg.				

*Note: 8927 to 8930 ft.

TABLE 8. Coring Lower Devonian in Well X-1, Block 31.

Core no.	Bit no.	From	To	Ft	Recovery, ft	Time OB	Avg. min./ft	Weight on bit, lb.	Rotary rpm	Pump press.,psi	Gpm
1	WR496	8599	8623	24	24	7:28	18.7	4000-5000	74	400-500	60
2	WR613T	8624	8662	38	38	15:47	24.9	7000	75	750-850	35
3	WR613T	8662	8702	40	40	19:23	29.1	7000-8000	75	750-1100	38
4	WR613T	8702	8742	40	40	18:00	27.0	5000-7000	70-80	750-1100	30-40
5	WR613T	8742	8782	40	40	11:40	17.5	5000-8000	60-70	650	30-40
6	WR613T	8782	8822	40	40	13:40	20.5	5000-8000	75	600	30-40
7	WR614T	8824	8864	40	38.5	23:44	35.6	5000-8000	75	650-700	30-40
8	WR498	8864	8904	40	40	15:35	23.4	5000-8000	75	750	30-40
9	WR496	8904	8920	16	16	4:50	18.1	5000-8000	75	750	30-40
				318		130:07	24.7				

TABLE 9. Coring Ellenberger in Well W-1, Block 31.

Core no.	Bit no.	From	To	Ft	Recovery, ft	Time OB	Avg. min./ft	Weight on bit, lb	Rotary rpm	Pump press.,psi	Gpm
9	WR586T	10,491	10,529	38	37.6	14:59	23.7	5000-8000	80-100	100-375	30-40
10	WR586T	10,529	10,560	31	31.0	12:12	23.6	5000-8000	70-80		30-40
11	WR585T	10,560	10,600	40	40.0	14:32	21.8	5000-8000	70-80		30-40
12	WR585T	10,600	10,623	23	22.0	11:27	29.8	5000-8000	70-80	250-300	30-40
13	R2589	10,623	10,663	40	40.0	11:14	16.8	5000-8000	70-80	325-375	30-40
14	R2589	10,663	10,703	40	40.0	15:00	22.5	5000-8000	70-80		30-40
				212		79:24	22.5				

from about 40 sec to 210 sec, the lowest being the oil emulsion mud used in the Z-1 and the highest being the regular water base mud used in the first core taken in the X-1. The oil base mud viscosity varied usually in the ranges of 130 to 180 sec. There is no indication that viscosity variations affected the drilling rates of the diamond bit; good rates of penetration were obtained with widely varying mud viscosities.

Water losses of the muds used were low. The moderate fluid loss properties, of about 3 to 8 cc API, caused no difficulties. No difference in drilling rate could be ascribed to these moderate fluid loss variations.

The suspending qualities of a mud are important in diamond coring because of the low rates of circulation of the drilling fluid. Rates of circulation in regular drilling in West Texas approach 300 gpm; in diamond coring they are one-tenth to one-fifth of that amount. Thus a higher viscosity mud has inherent advantages for removing the fine cuttings from the hole. Also, a mud of moderate thixotropic properties, which will gel and prevent settling during round trips and will rise to moderately higher viscosities under the low rates of flow, the usual limits of ease in breaking circulation after lowering the drill pipe in the hole and ease in pumping with low pressures governing acceptable ranges, would seem to embody desirable features.

The pump pressures used were in each case dependent upon the rate of circulation of the mud, and, of course, its viscosity and density, the drill string used in the coring, and the action of the bit in drilling. In the Upper Devonian of the Z-1 pressures varied from 100 to 350 psi, with an average fluctuation of 50 psi with each pump stroke. In the Lower Devonian of the Z-1, pressures were in the mean range of 300 psi, with a fluctuation, of from 250 to 425, or 175 psi, with each pump stroke. In the Ellenberger of the W-1, pressures were in the range of 200 to 300 psi, with a fluctuation of about 75 psi with each pump stroke. In the X-1, using oil base mud, and with a float valve in the drill string, pump pressures were in the range of 600 to 800 psi, with a fluctuation of about 350 psi, as from 750 to 1100 psi, with each pump stroke. In the X-1, all the flow discharge went to the bit during the first two cores. Following that, a part of the mud was bypassed through the guns on the mud pits; however, little if any improvement was made in giving a steady flow of mud to the drill pipe. It was found possible to slow the mud pumps down to 12 or 14 rpm, but they could not be run slower than this, and at that speed they did not run steady but loped with the fluctuations of their load. The most satisfactory way found of running the regular rig pumps was with both discharge valves removed from one of the double acting cylinders, leaving the other double acting cylinder to do the pumping. The pumps were, generally speaking, unwieldy.

● **Diamond bit wear and failures.** The diamond bits used were subject to failure both through damage to the bit and through normal wear, and from a combination of damage and wear. Of the two 6⅛-in. bits used in the chert in Well Z-1, the first was badly worn on its outer shoulder—the outer edge of the cutting face. This may have been caused by small fragments of chert that were wash-

FIG. 2. Well Z-1, University Block 31, Lower Devonian.

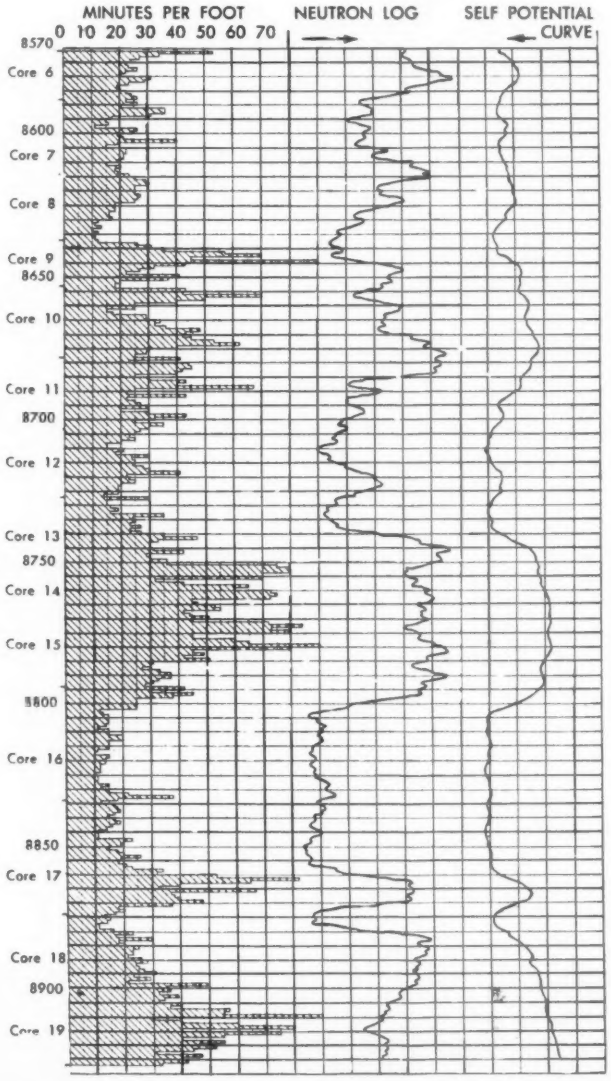

FIG. 3. Well X-1, University Block 31, Lower Devonian.

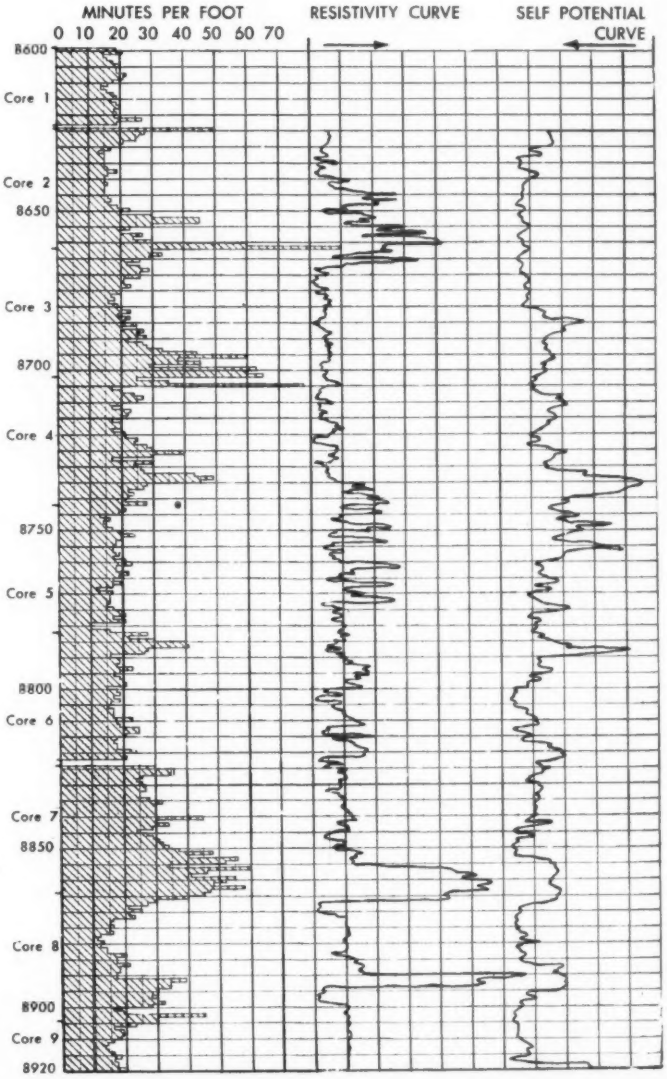

TABLE 10. Record of diamond bits used in Z-1, X-1, and W-1, Block 31

Bit no.	Well where used	Total footage drilled	Total hr rotated on bottom	O D, in.	I D, in.	Diamonds used in bits			Original cost	Diamond salvage value	Net cost less freight	Bit cost per foot drilled	Remarks
						Original carats	Salvage						
							Carats	Per cent					
WR459	Z-1	41	15.7	6⅛	3 17/32	139.73	13.65	9.8	$1,583.98	$ 102.37	$1,481.61	$36.10	Bit worn on outer shoulder.
WR460	Z-1	33	16.2	6⅛	3 17/32	138.68	105.92	76.4	1,576.10	794.40	781.70	23.65	Finished core.
WR310	Z-1	199	114.3	4 25/32	3 1/16	103.97	61.60	59.3	1,301.40	462.00	839.40	4.22	Diamonds exposed.
WG311	Z-1	104	42.0	4 25/32	3 1/16	103.92	71.42	68.7	1,765.04	857.04	908.00	8.72	Diamonds exposed and missing.
WR497	Z-1	53	31.8	4¾	3 1/16	107.76	77.90	72.5	1,326.20	584.25	741.95	13.72	Diamonds exposed.
WR586T	W-1	69	27.2	4 25/32	3 1/16	104.91	85.30	81.3	1,304.83	639.75	665.08	9.65	Diamonds exposed.
WR585T	W-1	63	26.0	4 13/16	3 1/16	101.60	72.74	71.7	1,280.00	545.55	734.45	11.67	Diamonds exposed and missing.
R2589	W-1	80	26.2	4¾	3 1/16	123.78	106.38	86.0	1,246.35	797.85	448.50	5.61	Finished core.
WR613T	X-1	198	78.5	4 13/16	3 1/16	100.10	.....	40.0*	1,268.75	300.00*	969.00	4.90*	Diamonds exposed, inner shoulder damaged in uncoupling.
WR614T	X-1	40	23.7	4 13/16	3 1/16	94.54	.....	50.0*	1,227.05	364.00*	863.00	21.60*	Diamonds missing on inner shoulder and bottom center. Shank scored.
WR498	X-1	40	15.6	4¾	3 1/16	116.58	52.00	49.8	1,395.21	390.00	1,005.21	25.15	Diamonds broken on bottom. Shank scored. Junk slots battered.
WR496	X-1	40	12.3	4¾	3 1/16	104.33	.....	80.0*	1,307.87	626.00*	682.00	17.10*	Finished core.
12 bits	3 wells	960	429.5	.....	.....	1,339.90		64.0	16,582.78	6,463.21	10,119.90	10.53	

*Estimated values. Total express, $37.19.
Cost of 6⅛-in. bits per ft=$30.60
Cost of 4¾-in. bits per ft=$ 8.86
Cost of diamonds: R quality at $7.50 per ct.; G quality at $12.00 per ct.

ed to the outer periphery and there ground under the bit, or it may have been largely caused by the high weights carried on the bit. Actually, the bit cut 41 ft, and much of that was hard, tough chert. Its performance is considered good, although a total of 90 per cent of the diamonds were missing or broken too small for salvage. The second 6⅛-in. bit finished the core, cutting 33 ft with only 24 per cent of the diamonds damaged.

The three 4¾-in. bits used in the Z-1 cut 199, 104, and 53 ft respectively. The first bit, which cut 199 ft wore out in a normal manner. The metallic matrix gradually was eroded by mud flow or worn by abrasion of the cuttings. With each run, the diamonds protruded farther from the matrix. Diamonds are brittle, and protruding and unsupported diamonds are much more likely to break than are well supported diamonds. Broken diamonds are not credited for salvage. Obviously, there is some optimum point beyond which a bit should not be run, some point beyond which salvage value of diamonds decreases more rapidly than it would cost to buy and run a new bit. The probability of an ultimate and complete failure of a bit increases with increased wear on the bit. No fine scale is available for determining when to stop running a diamond bit; it is not always possible to see the breaks or cracks that may have developed in the diamonds. It remains a matter of judgment. Generally speaking, when the diamonds protruded slightly less than 1/16 in. from the matrix, the bits were considered to be worn out.

The second 4¾-in. bit used in the Z-1 was of higher quality diamonds than the other two, but again failure was through erosion and abrasion of the matrix. There was no advantage in using the higher quality diamonds. The third bit was proceeding to wear in a normal manner when the coring of the Z-1 was completed.

Of the four 4¾-in. bits used in diamond coring the X-1, one bit wore out in a normal manner by gradual erosion of the matrix. It had cut 198 ft, but was considered good for another run. At the beginning of this run, the core barrel stuck and the bit was pulled and damaged on its inner edge during uncoupling when it was held over a sub on the rotary table. The bit had taken essentially all the wear it was good for, however, before being damaged further in the uncoupling. The next two bits were damaged by fragments of metal or hard rock, with diamonds gouged out and their shanks deeply scored and, on the latter, the junk slots battered. The last bit finished the core in good condition with wear proceeding in normal manner.

Three 4¾-in. bits were used in the deepening of the W-1. The first two bits cut 69 and 63 ft, respectively, and wear on the bits seemed more severe in the larger crystalline dolomite than in the smaller crystalline limestone. The third bit used in the W-1 cut 80 ft and showed very little wear either on diamonds or matrix.

● **Results of the coring operations.** *Cores.* The core recoveries obtained were in most instances 100 per cent. The lengths of unbroken pieces varied from ¼ in. to 7 ft, and between 2 and 3 ft would perhaps be a mean average length. In most cases the broken ends of the individual pieces fit together; in a few instances the broken ends did not fit together and it was obvious that small chips had been knocked out and ground up under the bit. Even in those cases where the ends did not match, no appreciable length of core would be missing. The lengths of core recovered in making successive core runs were sometimes greater and sometimes less than the amount of hole cut. The explanation of this seems to be that the core catcher sometimes slides a few inches up over the core before it grabs hold and breaks the core off bottom. About 18 in. was the maximum length of core noted to be missing in this manner. Lengths of 1, 2, or 3 in. probably occurred all the time, and were particularly noticed in runs 15, 16, and 17 in Well Z-1. The pieces left on botton were recovered as the top of the next core run.

In two instances pieces of core were recovered that showed where the diamond bit had cut in a second path in addition to the original core cut. The first occurrence was between Cores 18 and 19 in Well Z-1. The rock was black dense limestone and no damage was done to the diamond bit. A piece about 3 in. long was re-worked by the bit until it slid up into the inner core barrel. The second instance was between Cores 7 and 8 in Well X-1. The rock was fractured chert, and the diamond bit was gouged and scored and the water courses battered. The bit cut only the one core, and was not re-run.

The cores of the Devonian formation were generally firm and of sufficient strength to stand rough handling. Their tendency was to fracture horizontally, and there was little tendency to wedge in the inner core barrel. Some wedging did occur by small chips and some by cores that did not cut absolutely straight but cut in a wobbly manner. This did not interfere with cutting core (at least not noticeably), but it required in some instances that the core barrel be shaken, hammered on, laid down, turned upside down, and otherwise worked with until the offending pieces shook free. For this reason it is concluded that a connection for water pressure should be made on the core barrel for the purpose of forcing stuck cores out with hydraulic pressure.

The cores of the Ellenberger formation had much less strength than the Devonian cores. Generally, they broke off in horizontal fractures, a peculiar sine wave fracture extending across the core. Lengths were, of course, random, and varied from a fraction of an inch to about 5 ft, with a mean length of about 2 ft. Two sections, one from 10,570 to 10,572 ft, and one from 10,575 to 10,577 ft, were badly broken into pieces about the size of an egg. There were porous lime streaks in the core, which were very weak as well as hard, blue dolomite containing calcite veins, and some zones were vuggy.

Productivity of wells. A new manner of completion of the Devonian wells in Block 31 was used in the Z-1 and the X-1. Casing was cemented above the

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in Adapters and Liner Hangers are **(1) Foolproof Setting Action** that assures the liner being set *right where you want it*—without the uncertainties of less positive methods that necessitate manipulation above or below the exact setting point . . . **(2) Positive Releasing Action** that assures *complete* release of the setting tool from the liner *before* pulling the run-in string out of the hole (particularly important with light liners) . . . and **(3) an Error-Proof Packing Unit** that *cannot be set prematurely* by bridges or tight spots in the hole—nor by lowering too much weight when setting the Liner Hanger Slips.

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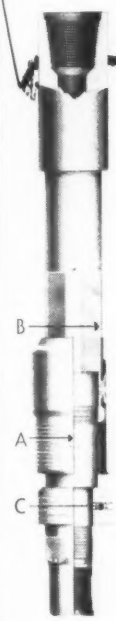


Regular Action

In this type of action, the Hanger or Adapter is supported by the coarse releasing thread of the "floating head" (A) on the Releasing Tool (see illustration at left). This floating head is rotated by the squared section (B), but is free to move up and down to prevent any "bind" being placed on the releasing thread during disengagement. When run in the hole, the ball bearing thrust washer (C) rests on a shoulder in the Adapter (or Hanger), thus providing a means of placing weight downward on the liner to hold it in place while the Releasing Tool is disengaged at the back-off thread.

The entire releasing action is unusually simple and foolproof. For example, when a Liner Hanger is used, the Hanger slips are first set by rotating the string to the left one or two turns to release the slips, whereupon lowering the weight wedges the slips firmly in place to support the liner. After pack-off operations (if any) are completed, release from the liner assembly is effected by simply applying 2 to 3 points of weight downwardly to hold the liner firmly in place, then rotating the string approximately 20 turns to the *right*. Since the back-off thread "floats" on the mandrel, it is free to move up or down to maintain perfect alignment while being disengaged—*and is completely unaffected by the weight being placed on the liner to hold it from moving*. Release is quick, positive!

Baash-Ross Security Regular Action Packing Type Adapter.

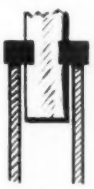
Baash-Ross Security Regular Action Packing Type Liner Hanger.

Other "Regular Action" equipment includes Plain Type Adapters and Plain Type Liner Hangers.

On all Packing Type Adapters and Liner Hangers special lock slips between body of packer and setting sleeve hold the packing element in expanded position after setting to insure a *permanent* leak-proof pack-off. Also, a choice of synthetic rubber or lead packing is available.

Delayed Action

Lugs Compressed



Lugs Expanded

"Delayed Action" equipment has the added advantage that the packing unit cannot be set prematurely by striking bridges or tight spots in the well—nor can it be set inadvertently by lowering too much weight against the tool while expanding the slips.

The equipment is run with a Delayed Action Packer Setting Tool attached to the bottom of the Releasing Tool (see right). This Delayed Action device has lugs that remain contracted within the setting sleeve of the packing unit (see sketch) until *after* the releasing thread has been disengaged.

The Adapter or Liner Hanger is set in the same manner as described at left for "Regular Action" equipment, and the Releasing Tool is also disengaged in the same manner—but is released *before* the packing element is expanded. To set the pack-off unit, the released run-in string is raised 4 to 6 feet to permit the lugs to expand. Then when weight is lowered back down, the expanded lugs seat against the top of the setting sleeve and compress the packing unit. The entire action is foolproof—and gives complete protection against premature pack-off!

Baash-Ross Security Delayed Action Packing Type Adapter.

Baash-Ross Security Delayed Action Packing Type Liner Hanger.

In both the Packing Type Adapter and Liner Hanger illustrated above, special lock slips between body of packer and setting sleeve hold the packing element in the expanded position after setting. This feature assures a *permanent* leak-proof pack-off. Also, both types of equipment are available in choice of synthetic rubber or lead packing units to meet varying operating requirements.

**Manufactured under license from Security Engineering*

main producing zone, which is the Lower Devonian, and which comes in at about 470 ft below the top of the Devonian. Coring was then accomplished in the cased hole and the core barrel and drill string were protected from the caving of the shales above the Devonian. This was particularly desirable because of the very low rates of drilling fluid circulation used in the coring. Previously, all the wells had been drilled with 8¾-in. rock bits, and the casing had either been perforated or cemented above the producing zone after the wells were drilled. It is therefore desirable to investigate the comparative productivity of the wells in the field to see whether the manner of completion, which was necessary chiefly because the wells were to be cored, has influenced the productivity of the wells.

It is also necessary to consider that special drilling muds were used in both the Z-1 and the X-1. Halliburton Jel Oil Type E oil emulsion mud was used in the Z-1 and Oil Base Black Magic mud was used in the X-1. Well completion advantages are claimed for both of these muds. The oil emulsion mud contains surface active agents that modify interfacial tensions and are thus supposed to aid the oil in forcing any filtrate from the mud back into the well bore when the well is brought in. Black Magic has no water filtrate and can therefore form no water block around the well bore to impede flow of oil in to the well.

The initial potential of the Z-1, exceeds the initial potentials of all its offset wells by amounts varying from 7 to 184 per cent. The X-1 exceeds the potential of all offset wells operated by Atlantic by amounts varying from 1 to 85 per cent, but is exceeded by diagonal offset of Phillips by 18 per cent. The productivity index of the Z-1 exceeds that of all its offsets. The productivity index of the X-1 is not presently available.

It may be mentioned that the initial potentials of the wells in the field do not fall into any regular pattern. The wells in the field are of the declining productivity index type. These facts make difficult an absolute proof that any particular type of well completion is better than another type.

● **Design advances in coring equipment.** The equipment used for diamond coring continues to be modified for various purposes. Advances known to have been made are:

1. Packing the bearing, which supports the inner core barrel, with lubricant. Besides lubricating the bearing, the bearing is sealed in so that if it should fail no bearing parts can be washed down under the diamond bit and ruin it. Such trouble has to date not been experienced by Atlantic.

2. Longer core barrels, up to 90 ft, which are fastened together with threaded couplings. It is understood that fabrication of these barrels has required a higher grade steel than has previously been used in the core barrels.

3. Reverse circulation coring has been accomplished by Stanolind at Rangely. This method seems to offer definite economic advantages for making hole in hard rock sections that have fast coring rates[1].

4. Another advance in diamond coring is the manufacture of diamond bits with a hard tungsten carbide matrix for supporting the diamonds.

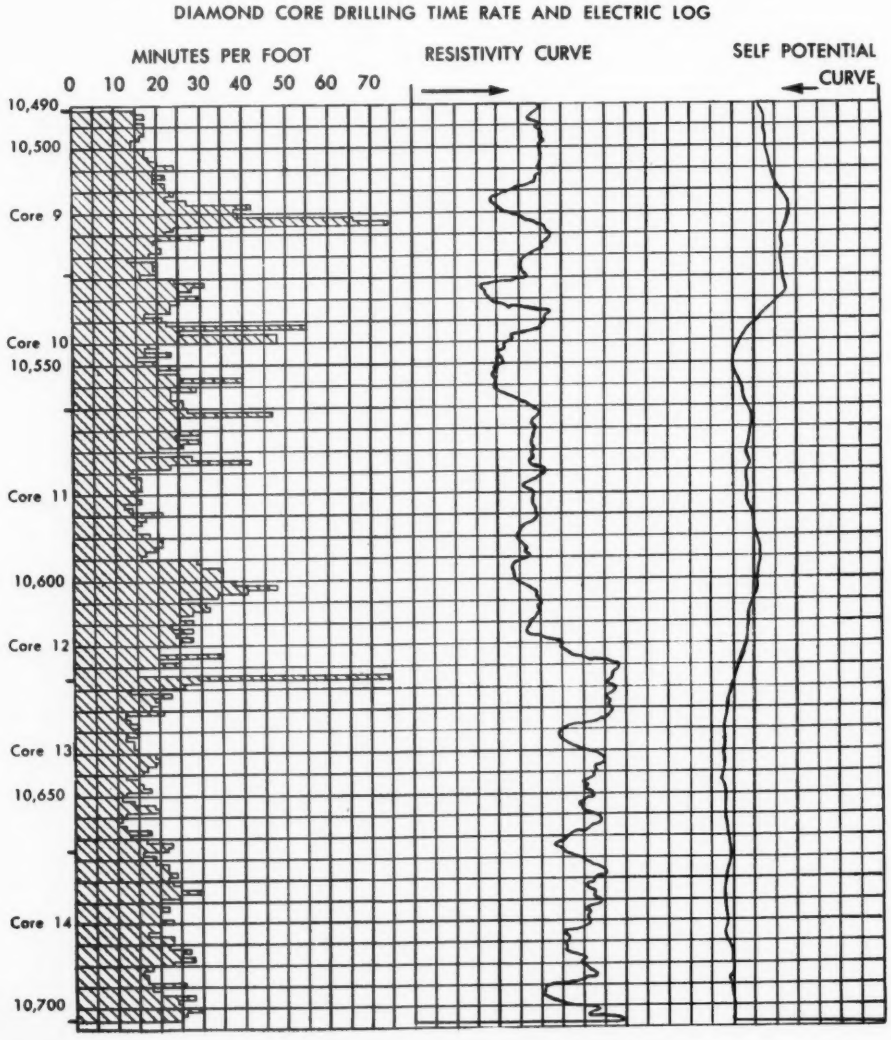
5. One type of core barrel is so manufactured that a portion of the drilling fluid flows up through the inner core barrel and thereby minimizes any tendency of broken core or fragments of core to wedge and interfere with drilling progress.

● **Analysis of drilling possibilities.** *Practical relations between length of core barrel and average drilling rates.* The time spent in coring may be divided into two parts: The time spent on bottom coring, and the time spent in making a round trip to remove the core from the barrel. It is obvious that the overall rate of making hole can be increased by taking longer cores. In order to see the relative advantages that might be obtained by using core barrels of increased length, Table 14 was computed. Only 6 hr was allowed for the complete round trip, a minimum figure for the 8000-ft level. It is felt that this figure gives maximum footages possible per day, although it somewhat reduces the relative advantage of longer core barrels. As the length of core cut increases the chances of jamming in the inner barrel or core catcher, and as a longer core run means longer time spent on bottom with the same bit, there are inherent risks that occur to make the chances of success in obtaining a full 90-ft core run considerably less than are the chances of success in obtaining a full 40-ft core run. Therefore, a definite advantage in overall rate of making hole should be indicated before deciding that the use of a longer core barrel is justified. The conclusion drawn from Table 14 is that until average drilling rates are increased to less than 20 min per ft, there will be but small advantage in obtaining core barrel longer than the 44-ft barrel now owned by Atlantic.

Possibilities with reverse circulation. Since reverse circulation diamond bit coring has been accomplished at Rangely, Colorado, and as better techniques may eventually speed up the cutting rates of the diamond bits in the West Texas area, it would seem desirable to make a calculation of what might be possible by using reverse circulation. The

1. "Diamond Coring in Rangely" by Carl J. Christensen, Stanolind Oil and Gas Company, Casper, Wyoming. Paper presented at Regional Meeting of the *AIME*, Denver, Colo., September 28-October 2, 1947.

FIG. 4. Well W-1, University Block 31, Ellenberger formation.



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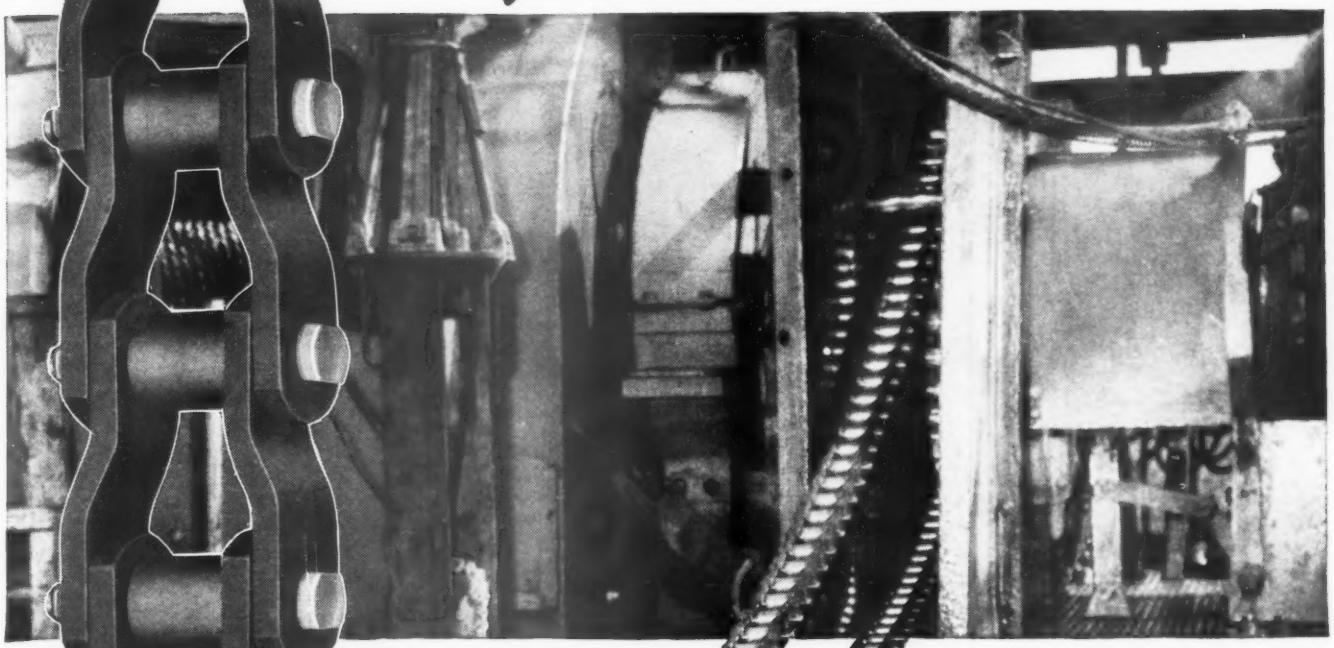

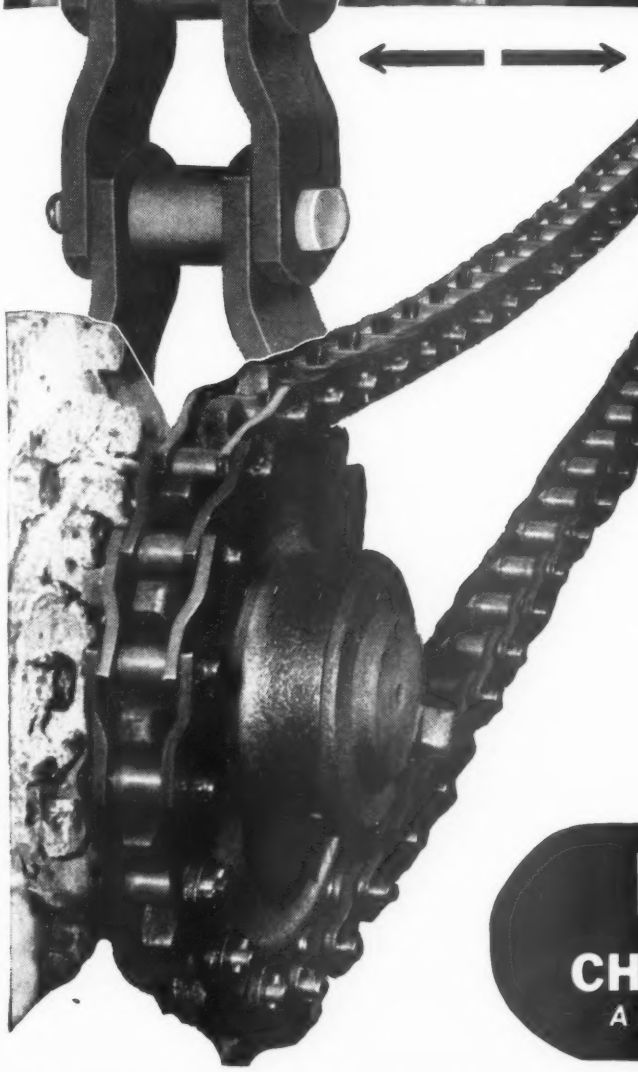

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TABLE 11. Time analysis of coring operations.

Well	Operation	Time start	Time stop	Time interval		Hours coring OB	Hours reaming OB	Average length cored	Average min./ft	Per cent coring time OB	Per cent reaming time OB	Per cent total time coring OB	Rate progress ft/day
				Days	Hours								
Z-1	Core 8141-8168 ft	0000 7-17-47	1500 7-18-47	1.63	39	9.18		13.5	20.2	24.6			16.6
	Ream and drill 8141-8169 ft	1500 7-18-47	1600 7-19-47	1.04	25							14.4	26.9
Upper Devonian	Core 8169-8217 ft	1600 7-19-47	1800 7-21-47	2.08	50	22.55		15.7	28.8	45.1			23.1
	Ream 8169-8217 ft	1800 7-21-47	0200 7-23-47	1.33	32							27.5	36.1
	(Total coring interval)			6.08	146	31.73		14.8	25.7	35.7		21.7	12.5
Z-1	Core 8571-8770 ft	0600 8-6-47	1800 8-14-47	8.50	204	104.80		22.1	31.6	51.4			23.4
	Fish junk	1800 8-14-47	1400 8-15-47	0.83	20								0.0
Lower Devonian	Core 8770-8930 ft	1400 8-15-47	1900 8-20-47	5.21	125	83.25		31.4	31.8	66.6			30.7
	(Total coring interval)			14.54	349	188.05		25.4	31.7	57.1		53.9	24.7
X-1	Core 8599-8623 ft	1800 9-11-47	1700 9-12-47	0.96	23	7.47		24.0	18.7	32.4			25.0
	Ream 8599-8623 ft	1700 9-12-47	1800 9-13-47	1.04	25		11.8				46.0	15.5	23.1
	Core 8624-8822 ft	0000 9-21-47	1400 9-26-47	5.58	134	78.50		39.6	23.8	58.5			35.5
Lower Devonian	Run and stuck and pulled core barrel	1400 9-26-47	1800 9-27-47	1.17	28								0.0
	Ream and drill 8624-8824 ft	1800 9-27-47	0100 10-3-47	5.29	127		73.0				57.5		37.8
	Core 8824-8920 ft	0100 10-3-47	1200 10-6-47	3.46	83	44.15		32.0	27.6	53.2		33.0	27.8
	(Total coring interval)			17.50	420	130.12	84.8	35.3	24.7	54.2		30.9	18.3
W-1	Core 10,491-10,703 ft	0100* 9-2-47	1800 9-18-47	6.83	164	79.24		35.3	22.5	48.3			31.0
Ellenberger	Ream 10,491-10,600 ft	1600 9-20-47	1700 9-24-47	4.04	97		60.0				61.9		27.0
	Total core, test, ream interval	0100 9-2-47	1700 9-24-47	22.67	544	79.24	60.0	35.3	22.5			14.6	9.4

*Cores were not consecutive in W-1, testing program.

average rate of coring at Rangely where the reverse circulation was used was about 10 min per ft. It does not seem likely that more than 300 ft could be cut without changing bits, although improved bits, with better technique, may soon commonly make 300 ft of hole. Assuming, then, 8 hr or one-third day for the round trip, and 10 min per ft for 300 ft, on bottom 90 per cent of the time, which equals 2.32 days cutting core, a total of 2.65 days would be required for 300 ft; and this equals a rate of 113 ft per day. These figures are perhaps optimistic, but there are no physical reasons why they are not possible. Two bits have already been run for longer total time than required by these figures. It should be obvious, however, that increased rates of penetration by the diamond bit is the first thing to be accomplished before additional thought should be given to reverse circulation coring. Without high rates of penetration, it has no real advantages.

Improving penetration rates of diamond bits. In searching for the reasons why the diamond core bits drill slow in some strata and fast in others, various properties of the rock may be considered. Properties that suggest themselves are:

1. Hardness. This is of necessity a property of the individual grains or crystals comprising the rock. On the scale of hardness, calcite, the mineral that forms limestone, is rated 3 and dolomite is rated 3.5 to 4. Sandstones are composed mainly of quartz, with hardness of 7, feldspars, hardness 7 to 6.5, together with minor constituents and cementing materials such as calcite. The diamond has a hardness of 10, being the hardest known mineral. The scale of hardness is not uniform, so that the relative hardness between diamond and quartz compared to the hardness between diamond and calcite would not be given by (10-6)/(10-3), but it would be ratio much nearer to unity. The absolute differences in hardness increase as the minerals are rated higher on the hardness scale. As different strata of limestone drill at widely different rates, varying from perhaps 6 or 8 to 90 min per ft, and as sandstones generally core at rates from 5 to 10 min per ft, much faster on an average than limestones or dolomites, it must be concluded that hardness is not a factor of the rate of penetration.

TABLE 12. Regular drilling of offset wells, Lower Devonian Zone.

Wells offsetting Z-1

Well	Corresponding interval	Progress rate, ft per day	Ft per bit
C	8500–8900 ft	20.0	25.0
F	8500–8900 ft	17.4	21.1
K	8500–8900 ft	17.4	19.1
N	8600–9000 ft	22.2	25.0
Y	8500–8900 ft	36.4	33.3
	Average	22.7	24.7

Wells offsetting X-1

Well	Corresponding interval	Progress rate, ft per day	Ft per bit
D	8700–9100 ft	22.2	30.8
E	8500–8900 ft	13.8	18.2
W	8500–8900 ft	25.0	33.4
	Average	20.3	27.5

2. Texture. The following attributes of texture are considered:

(A) Size of crystals or grains. It was observed that the very finely crystalline limestones were the slowest drilling of all the rock sections penetrated. Limestones and dolomites formed of larger crystals drilled faster. If the individual diamonds cut a gouge whose depth was dependent on crystal size, the correlation would be explained. There was no accurate means of measuring crystal size in the field, and no mathematical correlations could be developed. Sandstones, which drill faster than limestones, in general have grains whose size is considerably greater than the limestone crystals. On the other hand, the mineral of the finest crystalline structure, the chert, drilled at rates from 20 to 30 min per ft, or from 3 to 5 times faster than the finely crystalline

LESS SPACE

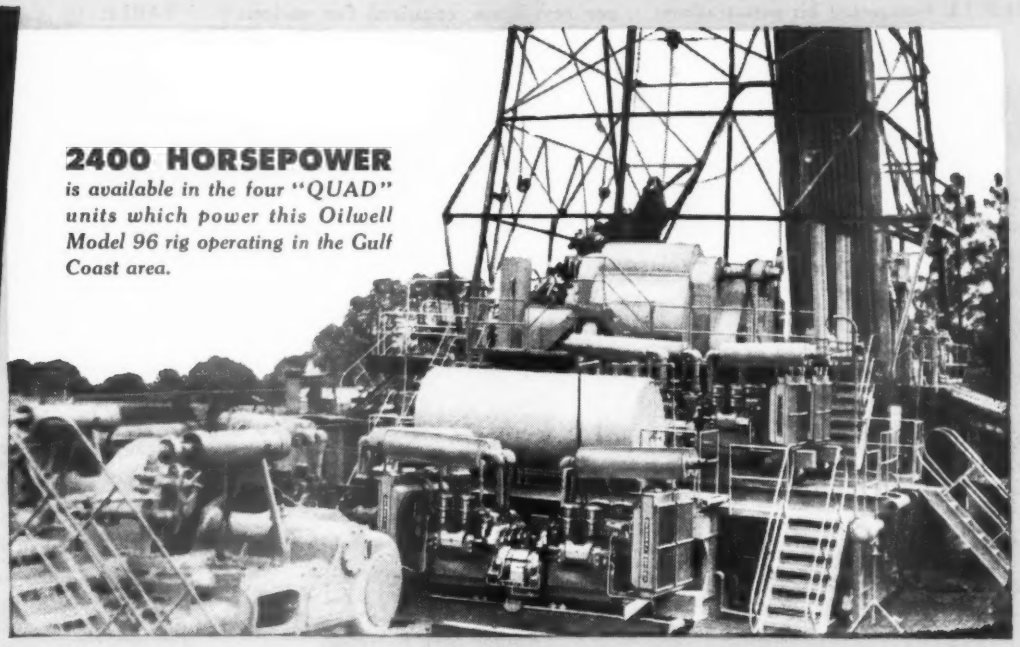

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TABLE 13. Computed bit penetrations per revolution required for various drilling rates.

Millimeters of penetration per bit revolution

Min. per ft drilled...	5	10	15	20	30	60	90
Revolutions per min.							
50	1.22	0.610	0.406	0.305	0.203	0.102	0.068
60	1.02	0.508	0.338	0.254	0.169	0.085	0.056
80	0.763	0.381	0.254	0.191	0.127	0.064	0.042
100	0.610	0.305	0.203	0.153	0.102	0.051	0.034

Thousandths of inch penetration per bit revolution

Min. per ft drilled...	5	10	15	20	30	60	90
Revolutions per min.							
50	48.0	24.0	16.0	12.0	8.0	4.00	2.67
60	40.0	20.0	13.3	10.0	6.67	3.33	2.22
80	30.0	15.0	10.0	7.50	5.00	2.50	1.67
100	24.0	12.0	8.0	6.00	4.00	2.00	1.33

Equations: $\text{Penetration, mm/rev.} = \frac{304.8 \text{ mm/ft}}{(\text{rpm})\ (\text{min./ft})}$

$\text{Penetration, thousandths inch/rev.} = \frac{12{,}000 \text{ thous. inch/ft}}{(\text{rpm})\ (\text{min./ft})}$

limestone. This fact is largely explained by the tendency of chert to chip out with a characteristic conchoidal fracture.

(B) Porosity: The correlations between drilling rates and the electric logs are direct evidence that either the absolute porosity or the size of the pore spaces, or both, correlate with penetration rates. These curves are the only quantitative relations developed between rock properties and drilling rates. The best correlation is between the electron log and the penetration rate in the Lower Devonian of the Z-1. The electron and resistivity curves are largely measures of the amount of conducting fluid (salt water) in the rock, and the fluid content varies according to the pore space available within the rock. Rocks having greater porosity not only have less material to be removed by the diamonds in the drilling, but the individual particles of the rock would not be as firmly bonded together where more pore space exists between them, and thus they could be removed more easily than from the denser rocks.

(C) Strength: This property has not been measured for the various rock sections drilled with the diamond bit. It is expected that strength would correlate with penetration rates as it reflected the density of similar strata.

(D) Resilience: This property has not been measured for the various rock strata, but it is expected that it would be a fruitful field of investigation for a full understanding of the manner in which the diamond bit works at depths of 8000 to 10,000 ft.

In summing up the factors that affect penetration rates in diamond drilling, it is concluded that:

1. Penetration rate is not related to mineral hardness.

2. Penetration rate is related to crystal or grain size, but the relationship is affected by manner of fracture and the degree of bonding between individual particles.

3. Penetration rate varies with the porosity, possibly because porosity reflects the degree of bonding between individual particles.

TABLE 14. Computed advantage of longer core barrels.

Length of core barrel—drilling rate—progress rate.

Basis: Computed on the basis of 6 hr for total round trip
All other time spent on bottom coring.

Ft core per run	Avg. min./ft	Per cent time, OB	Progress rate, ft/day
20	40	69.0	24.8
	30	62.4	30.0
	20	52.6	37.9
40	40	81.5	29.4
	30	76.8	36.9
	20	69.0	49.7
	10	52.6	75.8
60	40	87.0	31.3
	30	83.3	40.0
	20	76.8	55.4
	10	62.4	90.0
90	40	91.0	32.7
	30	88.3	41.1
	20	83.3	60.0
	10	71.4	103.0

The following factors have been previously mentioned under discussion of coring technique:

1. Penetration rate does not vary appreciably with rotary speeds within the range of 60 to 120, or is too small in comparison to other factors to be detected.

2. Penetration rate is responsive to increased weight on the bit up to some maximum that is dependent upon the type of rock being drilled.

3. Greater rates of penetration can be made using small constant weights on the bit than can be made by irregular application of greater weight.

The foregoing factors are those that are considered of importance in governing the design of drill string for the purpose of increasing the penetration rates of the diamond core bits.

● **Acknowledgments.** The writer wishes to thank The Atlantic Refining Company for permission to publish this article and the data contained in it. Acknowledgment of information received on diamond coring is made to C. Deely, Ed Williams, R. W. Stuart, and engineers of various operating companies in the West Texas area. ★★★

TABLE 15. Calculation of net coring costs.

Estimated direct cost of coring Upper Devonian Zone in Z-1, Block 31

Rig time (6.08 days, coring and reaming) ($750 per day)	$ 4,560
Diamond bits, 2, 6½ in. x 3¾ in., less salvage	2,273
Rock bits, reaming, 4 bits at $124	496
Service personnel	105
Alterations to 6½ in. core barrel, incl. $70.66 freight	88
Total	$ 8,31
Allowance for regular drilling:	
Rig time (2.37 days, reaming time÷0.5 day for extra round trips required for estimated 2 more bits used) ($750 per day)	$ 2,150
Rock bits, 6 at $124	744
	$ 2,894
Estimated net additional direct cost of coring	$ 5,423
Estimated net additional direct cost per ft cored $= \frac{\$5{,}423}{74} =$	$74

Note: Much of the rock cored was chert, 9 ft was solid chert. There is no known way of accurately estimating how long it would have taken to drill this by rock bits. The additional cost of coring may have been considerably less than herein estimated.

Estimated direct cost of coring Lower Devonian Zone in Z-1, Block 31

Rig time (14.54 days coring) ($750 per day)	$10,900
Diamond bits, 3, 4¾ in. x 3 in., less estimated salvage	2,490
Service personnel	105
Core barrel complete, 4¾ in. x 30 ft, incl. 15.33 freight	1,116
Core barrel tubes for 4¾ in. barrel, 44 ft	450
	$15,061
Estimated direct costs of regular drilling Lower Devonian Zone in Z-1, Block 31:	
Rig time: $\left(\frac{\text{359 ft interval}}{\text{22.7 ft/day, avg. of offset wells}}\right)$ ($750 per day)	$11,850
Rock bits: $\left(\frac{\text{359 ft interval}}{\text{24.7 ft/bit, avg. of offset wells}}\right)$ ($124 per bit)	1,800
	$13,650
Estimated net additional direct cost of coring	$ 1,411
Estimated net additional direct cost per ft cored $= \frac{\$1{,}411}{359} =$	$ 3.94

Estimated direct cost of coring Lower Devonian Zone in X-1, Block 31

Rig time (17.50 days coring and reaming) ($750 per day)	$13,100
Diamond bits, 4, 4¾ in. x 3 in., less estimated salvage	3,520
Rock bits for reaming, 6 bits at $85+1 bit at $124	634
	$17,254
Estimated direct cost of regular drilling Lower Devonian in X-1, Block 31:	
Rig time: $\left(\frac{\text{318 ft interval}}{\text{20.3 ft/day, avg. of offset wells}}\right)$ ($750 per day)	$11,740
Rock bits: $\left(\frac{\text{318 ft interval}}{\text{27.5 ft/bit, avg. of offset wells}}\right)$ ($124 per bit)	1,284
	$13,024
Estimated net additional direct cost of coring	$ 4,230
Estimated net additional direct cost per ft cored $= \frac{\$4{,}230}{318} =$	$13 40

Net direct coring costs on W-1, University Block 31

Basis: Rig time is charged only for coring time. Reaming time is not included because the reaming was performed after all coring was successfully accomplished.

Rig time (6.84 days coring) ($850 per day)	$ 5,820
Diamond bits	1,848
	$ 7,668
Cost per ft of hole cored $= \frac{\$7{,}668}{212 \text{ ft}} =$ $36.20 per ft	
Allowance for regular drilling:	
Rig days $\frac{(212 \text{ ft})\ (39 \text{ min/ft})}{(1440 \text{ min day})} =$ 5.74 days O.B.	
(6 trips) $\left(\frac{7.5 \text{ hr/R.T.}}{24 \text{ hr/day}}\right) =$ 1.87 days R.T.	
7.61 days total	
Rig time (7.61 days) ($850 per day)	$ 6,460
Bits, 3 bits at $94	282
	$ 6,742
Net additional direct cost of coring	$ 926
Net additional direct cost per ft cored $= \frac{\$926}{212} =$	$4.37

Note: Wells A-1, B-1, C-1, E-1, F-1, G-1, J-1, and K-1 were drilled into the Ellenberger with an average rate of 39 min. per ft using an average of 2 bits each in the Ellenberger.

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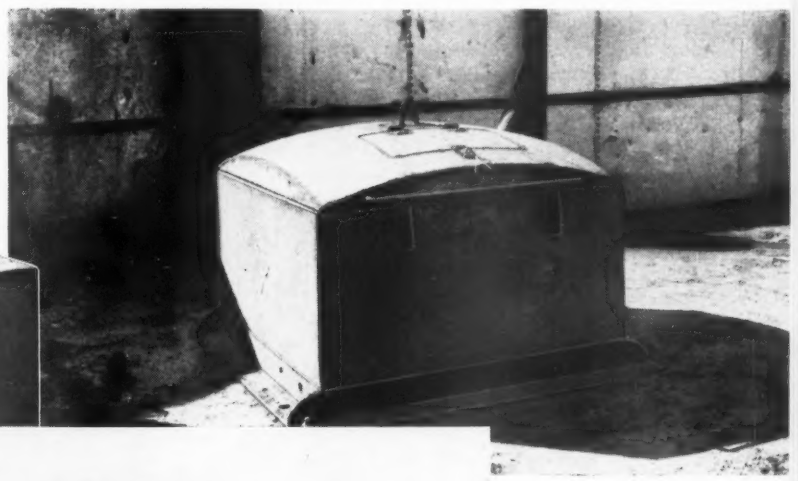
**This figure is based on an industry study by Kobe's General Technical Service Division which is available to you.*

SOLVES DIFFICULT INSTALLATION PROBLEMS, TOO!

Below are photographs of an unusual *Free Pump* installation in the South Canadian River bed near Sasakwa, Oklahoma. The steel box built around the wellhead is designed to protect the unit against floods, which previously carried away the derrick.



1. Free Pump wellhead is shown as it appears inside the steel box. Pumper has his hand on 4-way valve handle.
2. In this view, with top closed, the unit is secured for high water conditions.
3. Installation, as it appears in river bed.

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CONTROL OF

Narrow boiling range fractionating columns*

By G. G. GALLAGHER, Universal Oil Products Company

PRESENT day petroleum refining practices are working toward a higher and higher degree of separation of the narrow boiling range hydrocarbons; hence more accurate and more direct methods of instrumentation and control are required.

G. G. Gallagher

The usual means of temperature and pressure control, long used on ordinary fractionating columns, are not adequate for the super fractionators now encountered.

Fig. 1 shows a deisobutanizing column that fractionates isobutane from normal butane.

At 110 psi column pressure, there is only 23 F difference between the boiling point of pure isobutane and that of pure normal butane. On this basis a change of only 1.0 F in column temperature will cause a change in composition of approximately 4 per cent. From this it can be seen that the accuracy required is hardly possible with present day temperature controllers. Even then, holding the temperature alone constant will not suffice, for the purity of the product overhead may also vary in the order of 2 to 3 per cent with a change in pressure as small as 1.0 psi. Changes in barometric pressure alone can be responsible for variations of several per cent in the purity of the overhead material. From this it can be seen that it is important to maintain *both* pressure

*Presented before the Chicago Section of the Instrument Society of America, February 3, 1947.

FIG. 1. Deisobutanizing column that fractionates isobutane from normal butane.

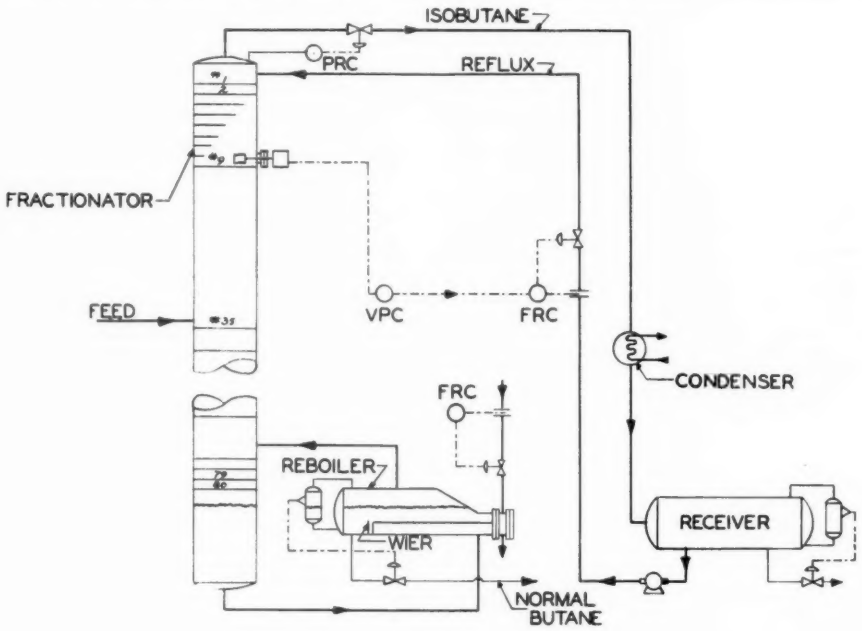


FIG. 2. Vapor pressure balance.

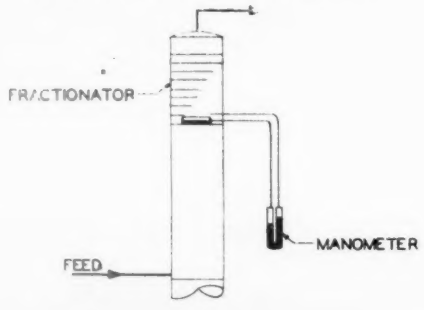
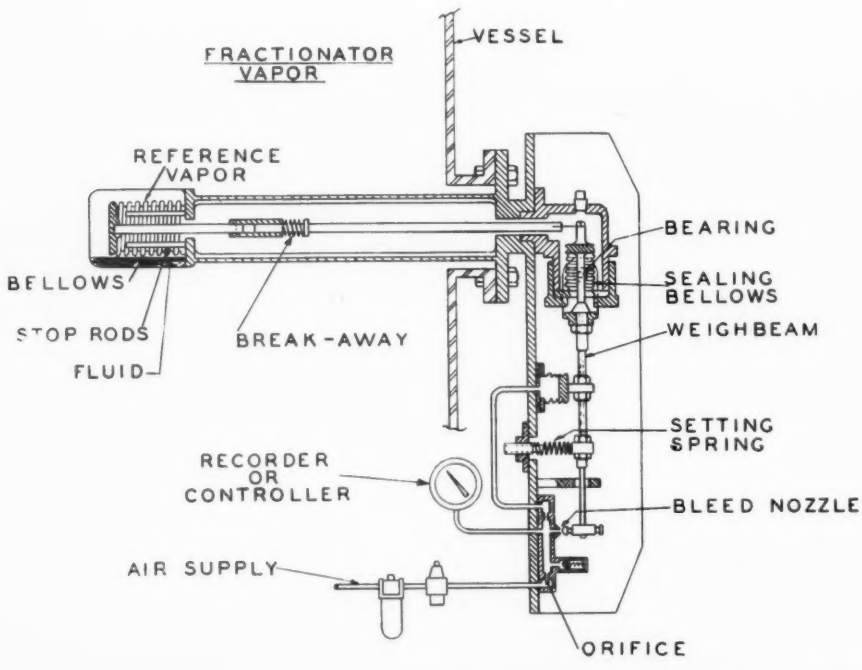


FIG. 3. A vapor pressure transmitter.



Oleum Refinery

PETRO-CHEM HEATER When Oleum's Unit 200, called a delayed coking unit, goes on stream early this fall, Union Oil Company will unveil one of the newest designs in petroleum processing heaters, the second one of its kind in service in the Bay Area.

Unlike the conventional tube-still heaters seen in refineries, the Petro-Chem version employs vertical tubes mounted in an upright cylindrical steel structure (above), with an integral stack rising vertically from the combustion chamber. This type of construction uses less of a refinery's valuable space. The heater has been designed to handle 19,500 barrels a day of crude petroleum, has an external diameter of 19 feet, and a total height of 105 feet.

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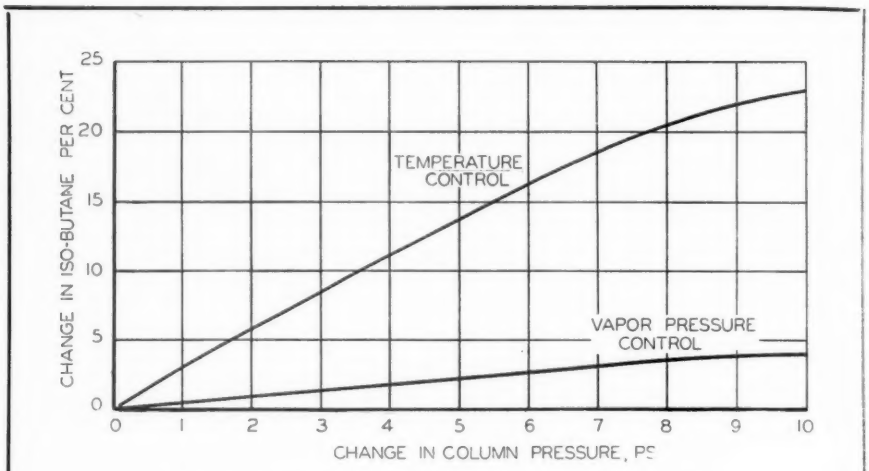


FIG. 4. Composition change on control tray vs column pressure deviation for binary column using vapor pressure controller or temperature controller.

and temperature within very close limits. As temperature and pressure controllers with the required accuracy were not available, a search was made for a better method of control. What was most desired was a composition controller that would make the necessary adjustments to the process for variation in column temperature, pressure, feed composition, or feed quantity.

One method that has been developed for controlling such narrow boiling range columns is commonly known as a vapor pressure controller, although on strictly *binary* columns it is essentially a *composition controller*. This instrument consists of a temperature bulb and pressure connection, both being situated at the same point in the column (Figs. 2 and 3). The temperature bulb is partly filled with one of the materials being fractionated. This bulb when exposed to the column temperature will exert a vapor pressure against one side of the diaphragm or mercury U tube, the other side of which is opposed by the pressure of the column taken at the same point that the temperature sensitive bulb is situated. Whenever the material at this point in the column is of the same composition of that in the bulb, no differenial on the instrument will exist regardless of what pressure or temperature elevation is encountered. Conversely, by holding a zero differential pressure on the vapor pressure controller the composition on the tray will always be the same as that in the bulb.

By looking at curves on Fig. 4 it can be seen that with a constant differential on the vapor pressure controller there is very little change in composition even with wide changes in column pressure. In other words, with a 1.0 psi change in column pressure, the composition will only change 0.4 per cent instead of the 2 to 3 per cent encountered when using a temperature controller and assuming it holds the temperature perfect. Therefore, it may be said that this instrument can control composition within very close limits by controlling the differential pressure between the column and the bulb.

Although this method of control is satisfactory for binary columns, its use in columns of multi-component mixtures is somewhat limited and the limitations have not as yet been fully explored.

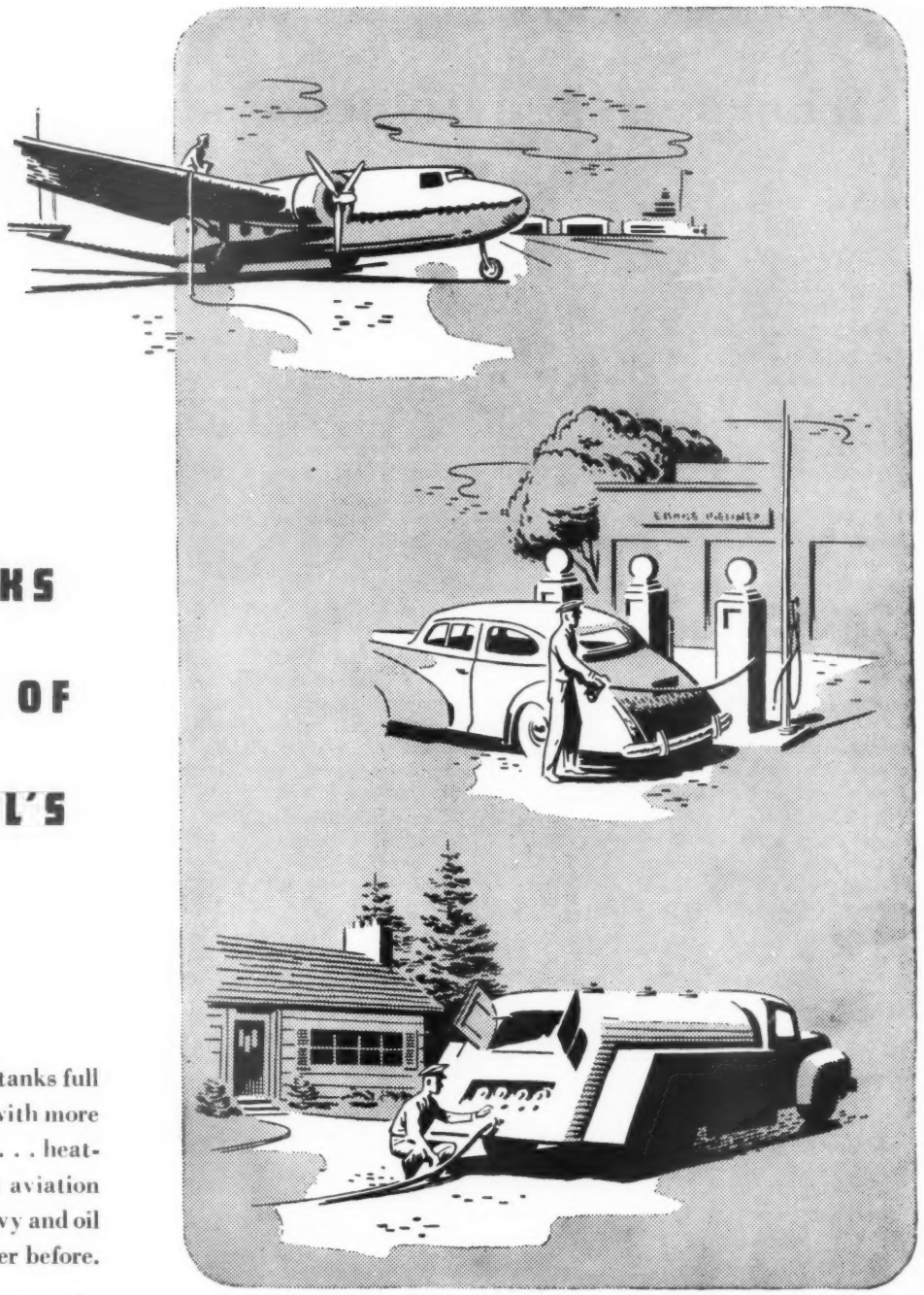
The petroleum and chemical industries have developed needs for new and revolutionary type instruments faster than the instrument industry was geared to keep in step. Several years after development of the need for a better means of controlling the multi-component columns, undesirable indirect methods of control are still being used because a satisfactory direct composition controller was unavailable. This is a definite challenge to the instrument industry to intensify its research and development along these lines. ★ ★ ★

Snowbound

The untimely snowstorm that recently swept over the Great Plains area marooned six men at the isolated No. 1 Schlochtermeyer, 15 miles from Great Bend, Kansas.

Snowbound for three days, rescue or relief attempts were made by land and by air. A bulldozer became stalled in the 12-ft drifts, while trying to reach the men. The CAP sent small army liaison planes to drop supplies and attempt rescue. An AAF helicopter stood ready.

Dan Cook, production superintendent for the Crown Oil Company, made his way from the well to a farm house a mile distant and telephoned for help.



FULL FUEL TANKS ARE PART OF UNIVERSAL'S JOB

Keeping the nation's fuel tanks full is a tough job these days with more people driving more cars . . . heating more homes . . . with aviation demands consistently heavy and oil doing more things than ever before.

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Universal Service Protects Your Refinery

Airborne magnetometer survey completed

THE world's largest flying magnetometer survey, made in a search for new oil fields for five major companies, was completed in Nassau. Approximately 85,000 sq mi in the Bahamas area were covered in this vast search for new oil reserves.

The survey centered about the airborne magnetometer, developed by the Gulf Research and Development Company, which is similar to a submarine-detecting device used by the U. S. Navy in wartime. In its peacetime role as a new geophysical exploration tool, the instrument records variations in the earth's total magnetic field. These variations are significant in locating oil-bearing geological formations, as well as ore bodies.

Final results of the oil search will not be known for at least three to five years. Further explorations must be made, with other geophysical tools. This information will be studied by company geologists, then further exploration and development work done within the concession areas held by each of the oil companies in the Bahamas.

The survey was made by the Aero Service Corporation of Philadelphia, Pennsylvania.

Mapping of the Bahamas area, which is larger than the entire state of Kansas, was especially complex. About 10 per cent of the area is land, 80 per cent shallow water, and 10 per cent deep water. Existing charts are old and inaccurate, and islands there are not visible one from another.

To guide the survey aircraft over this vast area precisely, the Aero Service Corporation employed another wartime device—Shoran. Shoran stations were set up aboard air-sea rescue type boats, which were anchored in pairs about 30 miles apart. They provided continuous triangulation to the plane flying in the general area. Shoran operating a pilot direction indicator so the pilot could guide the plane accurately along a chosen path.

Two flights daily of about 6 hr each were made, the survey aircraft taking off at dawn for the first flight. Each day the plane flew a distance equal to a round-trip flight, New York to Miami. Two complete five-men crews operated the survey plane, alternating flights. A special crew of mechanics kept the survey aircraft operating.

Aero Service's Bahamas staff numbered about 35 engineers, technicians, and flying personnel. In addition, Overseas Navigation Inc., which operated four Shoran mark-ships as sub-contractors for the survey, employed a staff of about 30 men.

An especially modified Douglas DC-3 was used as the survey plane, and a second DC-3 was held standing by for emergency needs. The airborne magnetometer was suspended from the plane by a 100-ft cable, which connected the instrument and its plastic container to the recording devices in the plane.

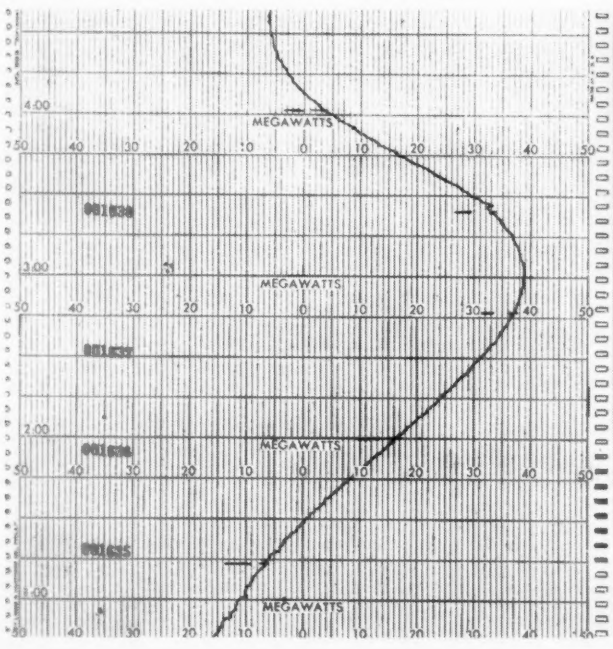
Recording of the variations in magnetic intensities of the area was done on a recording tape approximately 10 in. wide. More than four miles of such tape was used in the surveying. A total of more than 100,000 gal of gasoline were used in flying the Bahamas area. Approximately 20,000 man-hours will be required to translate the magnetic data obtained by the study into precise magnetic maps for the use of oil companies' geologists.

Robert Singleton of 404 Burd Avenue, Pennington, New Jersey, was the Aero Service Corporation project engineer for the survey. His assistant was Vernon Reynolds of Alden Park, Philadelphia. Homer Jensen of 1920 Pine Street, Philadelphia, chief of the magnetometer division, who participated in many of the early tests of the magnetometer as an exploration tool, was project manager.

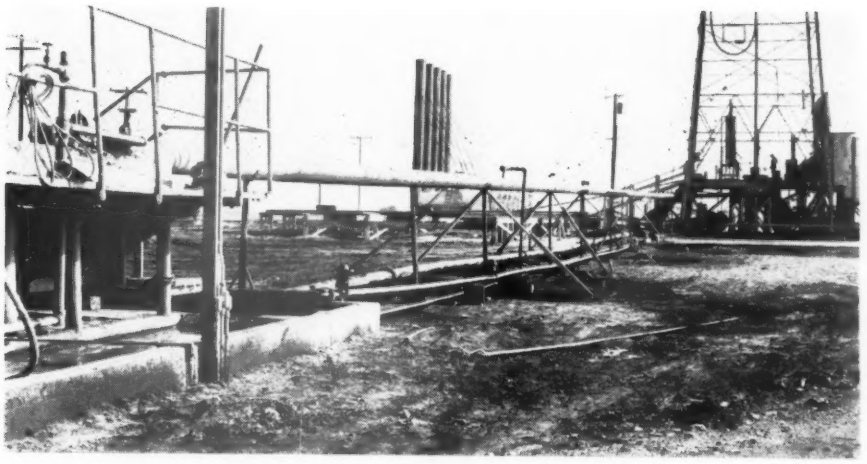
The following oil companies jointly contracted for the survey:

Bahamas Exploration Company, Ltd. (Gulf Oil Corporation); Standard Oil Company, (Bahamas) Ltd. (Standard Oil Company, N. J.); Shell Company of Bahamas, Ltd. (Shell Oil Company); Bahamas Oil Company, Ltd. (The Superior Oil Company), and Anglo-Bahamian Oil, Ltd. (Anglo-Iranian Oil Company). ★★★

Variations in magnetic field were recorded by airborne magnetometer on this tape, four miles of tape were used to map Bahamas.



Especially modified Douglas DC-3 used in survey. The "bird"—a plastic container that holds magnetometer—is suspended from plane by a 100-ft cable.



Mud line from shakers, at far left, to derrick.

Mud system design cuts skidding time

By JOHN C. ALBRIGHT

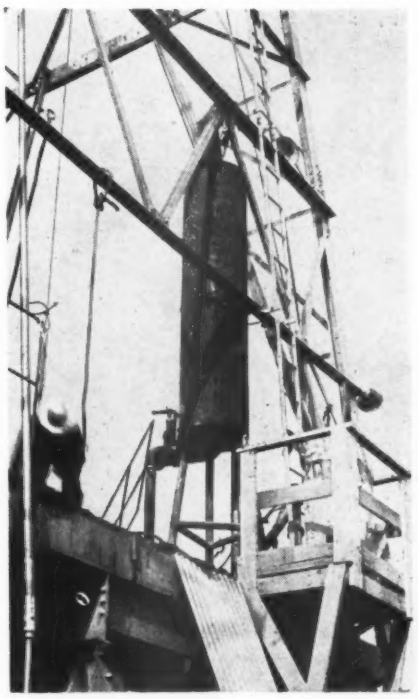
To SAVE time, equipment, and expense between drilling jobs, Southwest Exploration Company has designed a permanent installation for handling drilling mud while drilling a series of regularly spaced wells under directional control from the mainland to tidelands structures off-shore at Huntington Beach, California. These wells are 27 ft from each other on the surface, an adequate distance for production servicing, and the mud system is designed so that each successive well can be drilled to completion with a minimum amount of pipe fittings and connections to the ditch and the high pressure mud pipe lines.

EXCLUSIVE

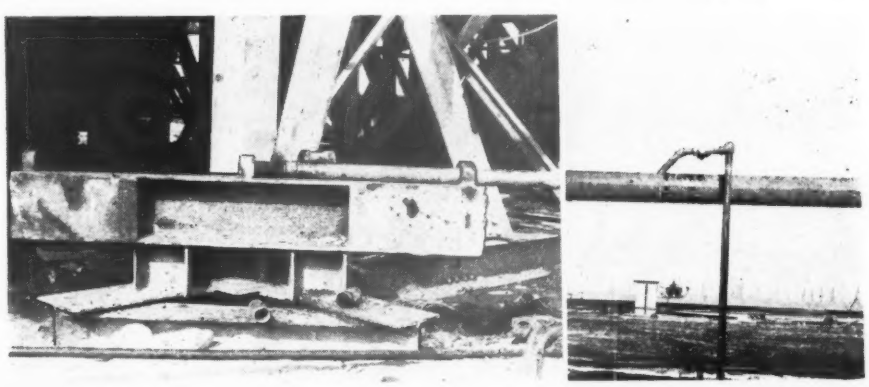
The derrick is designed for rapid skidding. It is mounted upon a high substructure to provide ample working space beneath the floor as well as gravity flow of the drilling mud and cuttings to a permanently located shaker assembly, shale pit, mud tanks, and two steam-driven mud pumps.

The shaker assembly is actuated by electric motors and is mounted upon a shop-built pipe structure having a skid type base that is set on a concrete pad adjacent to the shale pit. A wooden flume carries the shale-free mud across the open top shale pit, which is made of concrete, to a pair of concrete mud tanks constructed below ground level. Removable sections in the flume allows the mud to flow to either one of the mud tanks, or to both simultaneously as may be desired. A concrete wall divides the mud tanks, but they may be operated as one by opening a large gate valve on a short line passing through the dividing wall. The two tanks can be operated separately so that, when it is necessary to prepare a different type of mud to seal off and support a particular type of formation, one tank can be emptied quickly and the desired type of mud prepared directly in the empty pit while circulation is maintained from the other.

The two mud pumps have skid type bases resting on timber planking laid on the concrete floor of the pump pit, which is also below ground level. This design keeps the mud pumps under flooded suction. Piping to and from the pumps is laid on the concrete under the timbered planking, so the operator or member of the crew at the pumps may walk freely without stepping over any



Above, derrick floor surge tank used to keep hole full of mud when pulling drill pipe and to fill drill pipe or casing when running in hole.



Far left, wide footing at derrick corners to which flanged trucks are attached for skidding.

Left, jets to move settled shale and drill cuttings along mud flume from well to shakers.

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For these reasons, more Silver Top Slush Pump Valves have been sold than any other make on the market.

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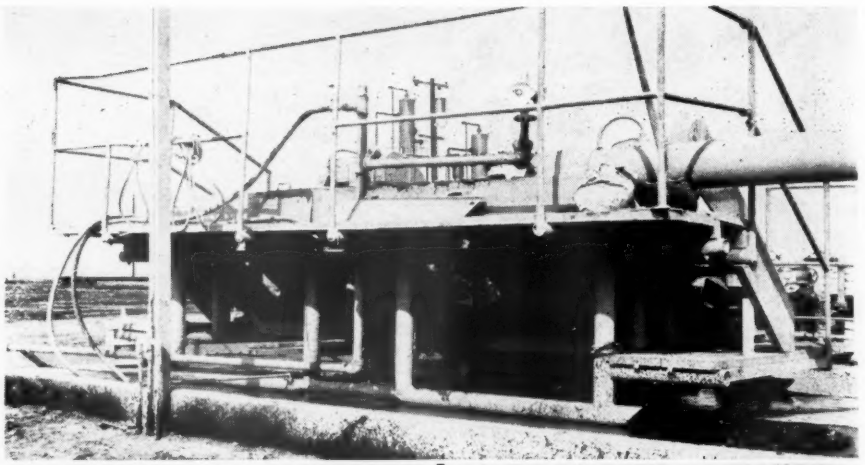
of the steam or discharge lines. The discharge from the pumps is conducted from the outlet to the hydraulic pipe line through a short section of mud hose to absorb shock and reduce vibration of the pumps and pipe lines. Switches to control the shaker motors are placed on a panel at one side of the pump pit to concentrate controls and to save the operators time.

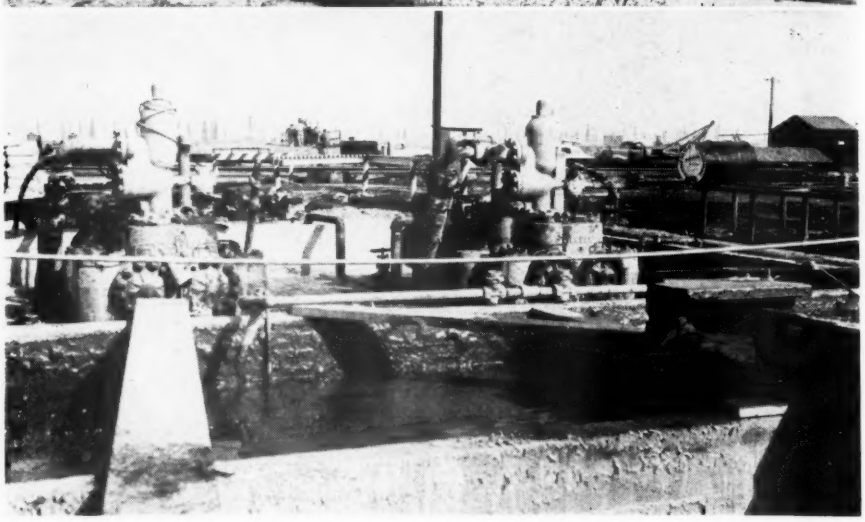
The mud returns from the drilling well flow from the equipment into a flume, or pipe, which forms the mud ditch by making a continuous line from the wellhead to the shaker assembly. The mud ditch is carried above ground on pipe standards with enough slope so that the mud will flow freely from the well to the shaker and mud tanks. This ditch is made with 27-ft sections, welded at each joint, so that cutting and rewelding to the fittings at the side of the derrick floor is all that is required for hooking up after the derrick is skidded to the next location. Should drill cuttings be produced in sufficient quantity to obstruct the free flow of the mud due to rapid precipitation in the pipe line flume, jets are installed at frequent intervals with connections at a tangent, so that mud pump pressure can be applied to set up enough turbulence to move the settled cuttings along the line with the mud to the shakers for separation from the drilling fluid.

The discharge line from the mud pumps to the derrick standpipe is laid upon the ground surface beneath the returns flume and is fitted with connections at 27-ft intervals so the derrick standpipe can be attached quickly at succeeding wells as drilling progresses on the property. Fittings on the pump line include welded collars at right angles to the line, closed with bull plugs, so that welding is unnecessary when making a new connection.

Included in the mud handling equipment is a vertical surge tank mounted on the floor of the derrick, which is used for filling the hole and casing when running pipe. The tank is made of 20-in. pipe set on a welded pipe tripod having a base sufficiently wide to support the tank, which is also anchored to the first girt of the derrick. The surge tank has fittings with valves and connections to the mud lines from the pumps and to a large overflow line near the top, which enters the flume, so that excess mud, or the entire circulation passing through the surge tank, will flow readily back to the mud pits. A convenient connection on the base of the tank facing the rotary table is used for attaching a hose that can be used to fill the pipe or the open hole as desired when the pipe is being run. As the surge tank is equipped with an overflow line large enough to handle the capacity of the mud pump, it is unnecessary for anyone from the crew to make frequent trips back and forth from the pumps to start and stop them during the time casing is being run into the hole. This saves the time of one man and speeds up the job of running pipe.

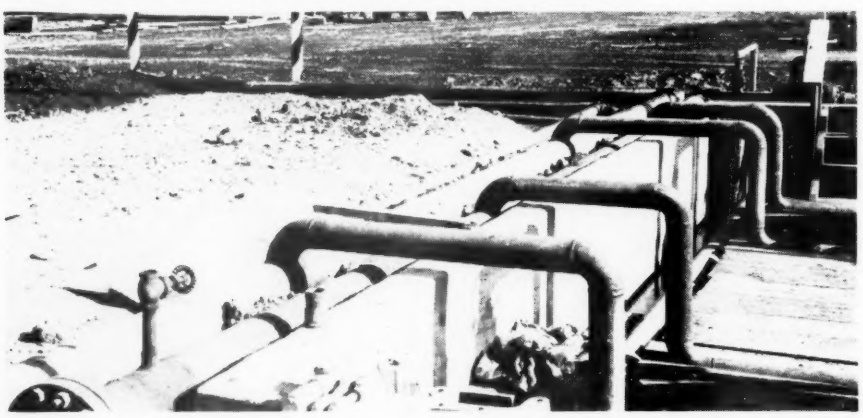
The derrick itself is built upon large web-type footings at each corner that rest upon a wooden mat or a concrete pad, depending upon the type of ground surface prepared for drilling. At the locations where the wells are spaced 27 ft from each other, a continuous concrete floor is poured prior to drilling, so that the wide footing of the rig sets directly on the monolithic slab of concrete. When the slab is poured, two rails of railroad iron are set on adequate footing, and flush with the surface of the slab, to be used afterward by a well-servicing derrick that may be removed easily from one well to another as required. The derrick used for drilling the wells is equipped with attachments on each corner footing so that, when skidding is necessary to move from a completed hole to the next location 27 ft distant, flanged trucks can be placed under the corner piers to set on the tracks after jacking up the rig. The entire rig structure can be moved easily across the slab of concrete on these tracks. ★★★





Top, shaker assembly of Southwest Exploration, Huntington Beach. Center, mud pumps and flume looking across mud tanks and shale pit.

Below, steam and mud piping crossing wall of the pump pit.



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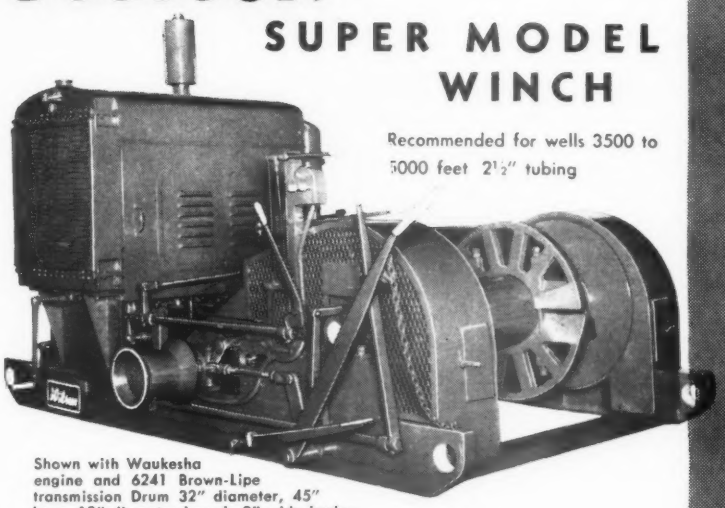

Shown with Waukesha engine and 6241 Brown-Lipe transmission Drum 32" diameter, 45" long, 13" diameter barrel, 8" wide brakes. Cut shows streamline guards on this machine.

SENIOR MODEL WINCH

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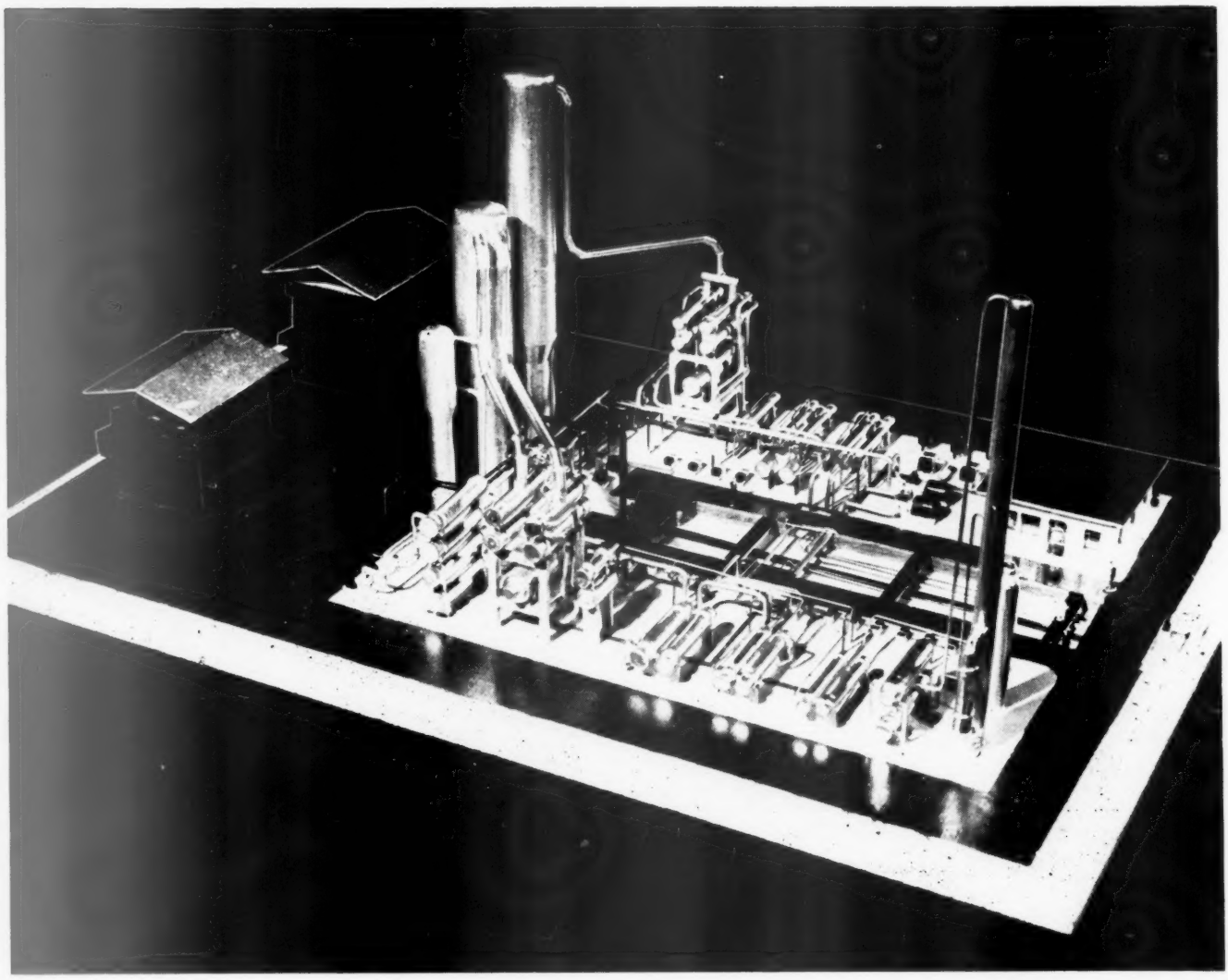


Model of crude oil unit.

Models for refinery design

By G. I. McBRIDE*

THE writer has participated in the design and layout of numerous refinery units and has concluded that it is difficult to design a clean, operational, functional, and accessible unit without using models.

EXCLUSIVE

This is not necessarily true in the case of the small refiner, where responsibility for design and operational facility is vested in one man, or in a small group of men. The writer is reminded of several such refineries where white-clothed operators have available a tiled control house and a grass plotted unit and produce profitable product revenues therefrom.

Among the major refineries of the country, however, this is not usually the case. There is no lack of competence in the personnel of their engineering departments. Inertia, distance, and insufficient time for personal supervision of detail are prime factors affecting the overall efficiency of the plant.

Inertia is a twofold enemy. Given responsibility for the development of a unit few engineers will fail to draw on their knowledge of an existing unit to serve as a guide. If the type of unit and the daily throughput are essentially similar, a site based on the area of an existing unit is chosen and usually approved. Design has not progressed appreciably as yet, but boundaries have been set that later will be difficult to change.

Within these boundaries a tentative plot plan is drawn. Management will approve a plot plan that conforms to previously successful installations. It is a weakness of drawings that innovations or radical changes cannot be portrayed with feeling. Hence, while the project engineer might be well aware of modifications and improvements that could be incorporated into his unit he is loathe to indicate these on the plot plan to be considered. He may plan to present improved design during the further development of the unit.

During this formative period the project engineer should have close contact with the operating department in order to avoid duplication of any features that have proved unwieldly in practice. This is seldom accomplished; the project engineer is at headquarters, the operator is busy at his plant any number of miles away. The distance factor is particularly pertinent at this point, for the engineer doesn't have enough information on the

*Drafting supervisor, Ehrhart and Arthur, engineers and constructors, Oakland, California.

board to justify a trip, and the operator is not in a position to visit headquarters to discuss a partially designed unit. Yet the very existence of the engineering department is dependent upon its ability to give the operators the units they need.

When the bulk of the preliminary development is completed the various drafting groups (sewers, foundations, structural, mechanical, electrical, and piping) lay out the plant detail. Now is the project engineer most needed to assist those in charge of the appearance of the completed plant. It never seems to fail, however, that just at this time, what with material procurement, substitution analysis, checking of process, comparison of quotations and deliveries, application of technical mechanics to flow sheets, with these and many other responsibilities the project engineer does not have sufficient time for supervision of detail.

Accompanying this article are photographs of a model of a hypothetical crude oil unit. The model was made to indicate to management how easily the engineering department could assemble a pleasing and symmetrical unit that could be thoroughly inspected and discussed without reference to any preceding unit. Furthermore, the operating department can offer suggestions with regard to a completed unit before time and money are spent to prepare detail drawings.

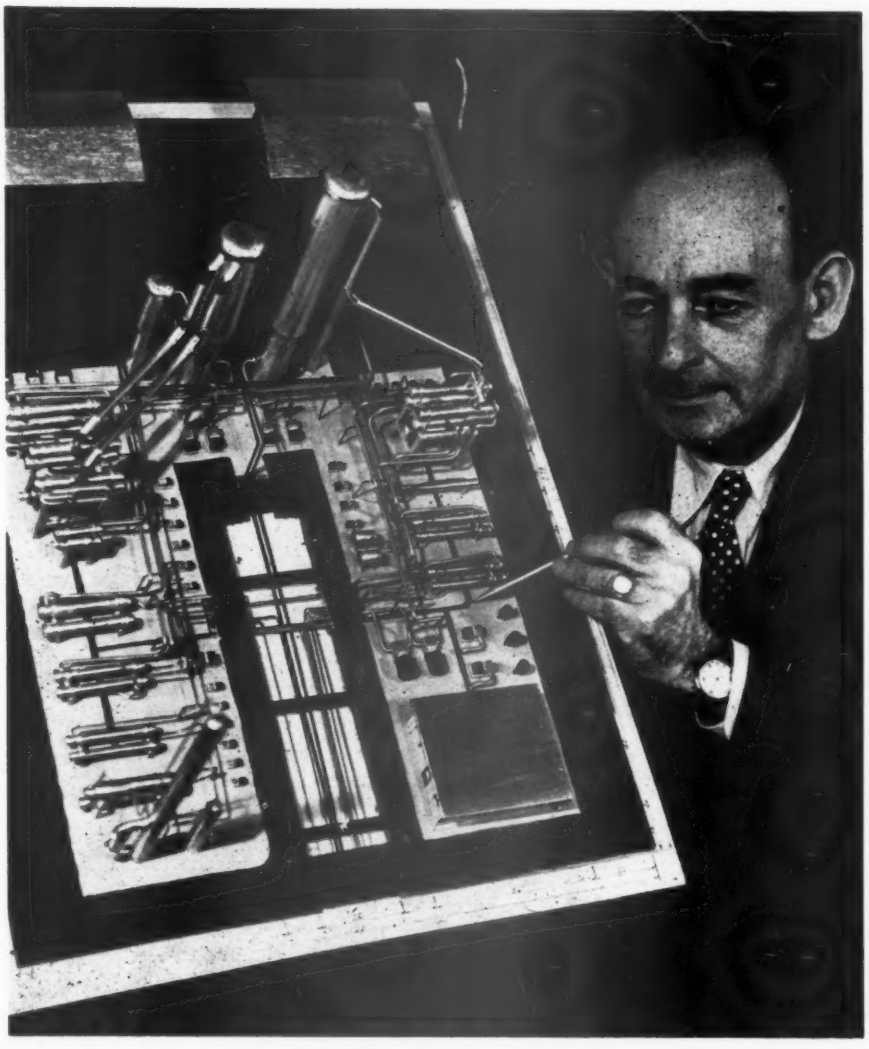
Model making has become quite popular in the development of other industrial plants, even where the design, superintendence, and operation are held in a closely knit organization. In present day refinery design, and particularly where a considerable portion of the detail is allotted to contract engineering firms, the need for a model as a basis for design seems even more compelling.

The writer is not aware of this method having as yet been put into refinery practice, so it might be well to review the design history of a present day plant.

Step one. Let us assume the building of a crude oil unit has been approved; oil has been analyzed, quantities set, flow diagrams made, and piping and instrument diagrams prepared. An area in the refinery is chosen and a plot plan drawn.

So far there has been little for the operating department to approve or disapprove. It may make some minor change in type of valve, or method of control as shown on the piping and instrument diagram, but essentially all the above can be "frozen" before the op-

The author pointing out features of a scale model.



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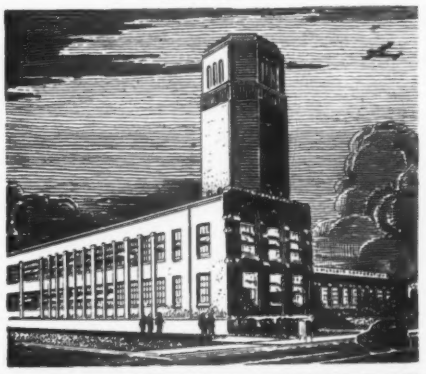

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erator knows how his plant will look.

Step Two. Column design has become so thoroughly standardized, that, given an approved plot plan, there seems no good reason why one should not set foundations and erect the towers. The same is true of the atmospheric and vacuum column exchangers and drums, and furnaces, hence, to save time, the area is graded and foundations poured.

Step Three. The piping department, which has been making "studies" of a changing plant is about ready to begin making final drawings. During the months it takes to arrive at this stage the research committee has decided to add more flexibility to the unit, so additional exchangers have been included; it has perhaps been decided to process an oil not originally considered, and certain sidecuts will be eliminated, demanding bypassing in the piping design.

Not until the piping and the pipe support drawings are complete does the operator get a real picture of his plant. Should he have any objection to the design it is now too late to make any major changes. The piping is largely predetermined from the plot plan; the plot plan was copied from an existing, eminently satisfactory, but not necessarily similar unit, and foundational concrete has already been poured.

The piping department for the new unit is usually assembled during the early stages of unit development. It is comprised of some six to ten men who make and revise tentative layouts until the piping and instrument diagram has been approved, perhaps some three or four months later. Hence from 1000 to 2000 manhours have been spent by the piping department before final drawings are begun.

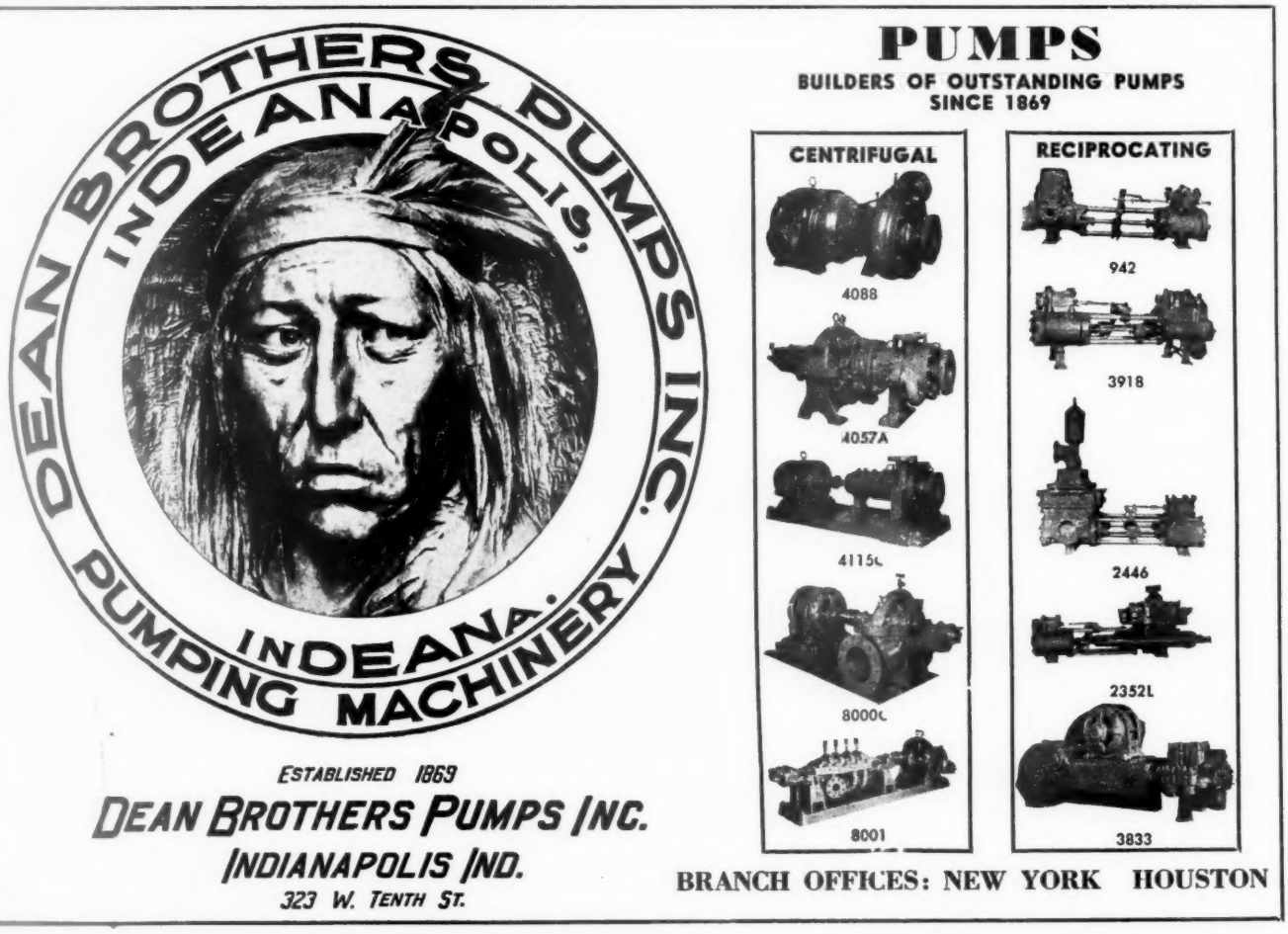
The model shown in the accompanying photographs took only 100 hours to make and assemble. It may be used to gain approval of the plot plan as well as to procure operating approval of final design. From it the piping department may start immediately on final layouts. Decisions that are normally made during the latter stages of design are made simultaneously with approval of the plot plan. Vessels are situated to accommodate the piping rather than vice versa.

Instead of presenting an innocent appearing plot plan to the chief operator, one that may later prove to have been unintentionally deceptive, one will note on the model:

1. Road accessibility of all pumps.
2. Functional location of pumps. Note how precisely the vacuum column bottoms, usually difficult to control, could be maintained by flow controlling pumps shown, and adding a level-controlled pair alongside.
3. Note the elevation and location of the flash drum, mounted above the vacuum column stripper, giving desirable head to the secondary feed pumps below, and permitting lowest possible operating pressure in the drum.
4. Permanent structures would serve the overhead exchangers, otherwise all are mounted at grade operating level for tube removal without platform requirement. This operational feature includes the rectifier cooler, which is shown under the accumulator.
5. All walks are at grade. There are no stiles.
6. The depressed walk is for block valve access and sample taking, the samples being analyzed in the adjacent control house.
7. Course of the instrument trough may be neatly plotted, in advance.
8. The troublesome problem of the cooling water supply is improved somewhat by almost burying it under the removable brick indicated. It might be decided upon inspection of the model to utilize overhead cooling.
9. Gas collecting trenches and hazardous areas are held to a minimum.

The writer contends it is economically impossible to show the above leading features of a refinery unit on drawings during the formative period of unit design. On the other hand, in making the simplest model of a refinery unit all of them must be shown, or at least indicated so that they are self-evident.

This is the writer's first attempt at refinery model-making; at 1/10 in. to the foot, it is too small. The units, turned out on the bobbin-spooler of a sewing machine had to be glued in place. One can visualize a storeroom of units, made to about ¼ in. scale, with pin connections and perhaps metal feet or base, which could be shifted about on a table until management, engineering, and operation had arrived at a mutual agreement. ★★★



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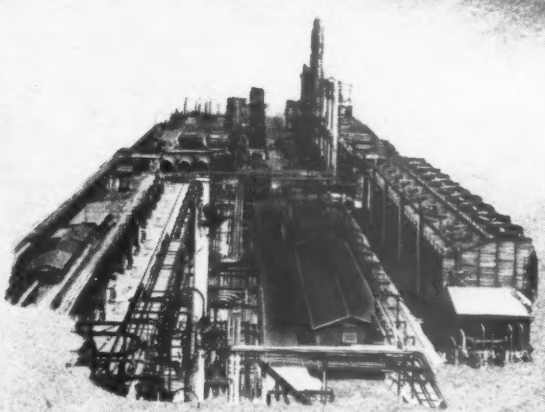

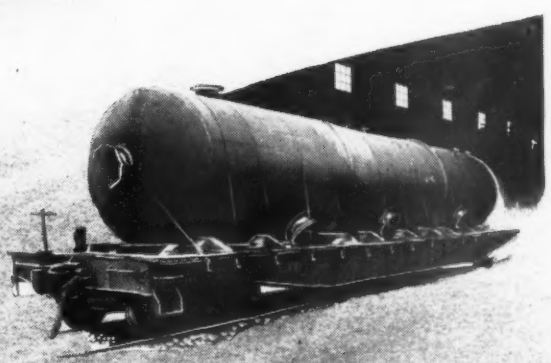

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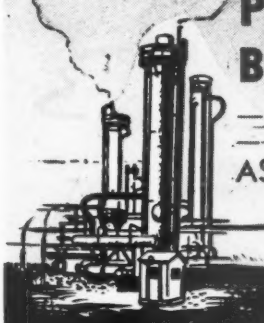

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MICHIGAN OIL FIELDS

Influence of spacing on ultimate recovery

By S. F. SHAW, Consulting Engineer

EXCLUSIVE

BECAUSE of the comparatively small volume of oil production from Michigan's fields, and also because of their proximity to highly industrialized centers where oil products are in great demand, there has not been the need for restricting oil production to the extent that has been necessary in most of the fields in many other oil-producing states.

New fields of consequence in Michigan have been restricted, however, when there has been the threat of waste that would result from large quantities of gas being discharged into the air. Also, in some older fields of this state it has been necessary to prevent salt water from finding its way into streams or lakes of fresh water, and this at times has made necessary the restriction of oil production. On the whole, however, the actions of the Conservation Board have been with the intent of interfering with the oil producers to the least extent possible, and only four fields are now on proration schedules.

The price paid for gas in Michigan fields is 15 cents per M cu ft, consequently, there is not the economic necessity for hesitating to install pipe lines to gather the gas as soon as a field has demonstrated that it will produce enough gas to make such a venture profitable. Where gas commands a price of only 3 to 5 cents per M cu ft, as is the case in several other states, there is not much incentive to extend pipe lines to the fields to recover the gas at low pressures.

In many fields of Michigan close spacing has often been practiced, the closest spacing since May, 1939, being 10 acres per well, and maximum extraction methods are often employed. These practices present sidelights that are interesting when compared with the trend of thought in many other areas where wide spacing has been adopted. It is inconsistent with sound economics to drill closely-spaced wells when the cost of drilling additional wells with accompanying slow pay-out could easily be the cause of a profitless operation. The degree of recovery in oil fields is not necessarily of the same importance as making the wells profitable.

With few exceptions, all the fields in Michigan are producing from limestone or dolomite formations in which it is very difficult to obtain accurate data on thickness and porosity of the producing formation. Because of this difficulty it is almost impossible to determine recovery factors that can be depended upon with any degree of assurance. Estimates of ultimate recovery based upon volumetric methods of computation are consequently very unreliable. As some of these fields with small initials per well are produced at maximum capacity, particularly where wells are drilled with close spacing, a reasonably uniform decline is often established. This enables an estimator to construct production decline curves that are reasonably satisfactory.

The table of estimates of ultimate recovery of several fields in Michigan, accompanying this article, is made up largely from production decline curves; but where no satisfactory decline curve yet can be constructed the estimates are taken from the *Oil & Gas Journal* of January 26, 1946. Data for acreage, thickness, and number of productive wells are taken from *AIME Petroleum Development and Technology* for 1946. This table is arranged in order of magnitude of well spacing. The first group covers fields with spacing programs of more than 30 acres per well, the second group includes fields with spacing ranging from 15 to 30 acres, and the third group shows spacing ranging from about 10 to 15 acres per well.

Comparisons of ultimate recovery for various spacing programs in Michigan oil fields, January, 1946.

No.	Field	Productive acres	Thickness, ft	Total number of producing wells drilled	Acres per well	Acre-ft	Estimated ultimate recovery		
							M. bbl	Bbl per acre	Bbl per acre-ft
	Group 1. Fields with spacing of 30 acres or more per well								
1	Norwich E.	2,600	9.2	36	72.2	23,920	2,600*	1,000	110
2	Woodville	400	4.5	7	57.2	1,800	407	1,017	226
3	Richfield	920	8.0	17	54.0	7,360	810*	880	110
4	Essexville	1,300	17.1	28	46.3	22,230	3,700*	2,840	166
5	Coldwater	2,440	13.0	55	44.3	31,720	6,300*	2,580	200
6	Fork	2,600	2.1	62	41.9	5,460	8,300*	3,190	1,520
7	Evart	1,120	5.7	28	40.0	6,384	4,075	3,640	638
8	Prosper	520	4.0	13	40.0	2,080	1,687	3,240	810
9	Goodwell	1,240	2.0	31	40.0	2,480	1,203	970	485
10	Kawkawlin	5,000	40.0	135	37.0	200,000	6,100*	1,220	30
11	Cedar	360	2.0	10	36.0	720	800	2,220	1,110
12	Headquarters	1,600	18.0	47	34.1	28,800	6,870	4,280	237
13	Winterfield	1,400	14.0	42	33.4	19,600	4,582	3,260	233
14	Rose Lake	600	5.0	18	33.3	3,000	1,744	291	58
	Total and average	22,100	16.1	529	41.7	355,554	49,178	2,220	138
	Group 2. Fields with spacing of 15 to 30 acres per well								
1	Reed City	5,280	15.0	203	26.0	79,200	75,201	14,250	950
2	Leaton	2,140	7.5	84	25.4	16,050	4,483	2,090	279
3	Clayton	1,320	12.0	60	22.0	15,840	5,732	4,330	361
4	West Branch	5,000	25.0	258	19.4	125,000	7,912	1,582	63
5	Bentley	920	2.5	49	18.8	2,300	1,800*	1,955	782
6	Mt. Pleasant	8,050	14.6	447	18.0	117,530	26,472	3,280	225
7	Beaverton, N. & S.	970	12.0	55	17.6	11,640	1,429	1,475	123
8	Temple	2,710	4.5	166	16.3	12,195	14,771	5,450	1,210
9	Tallmadge, S.	1,000	7.5	63	15.9	7,500	859	859	115
10	Porter-Yost	8,440	12.0	536	15.7	101,280	49,595	5,876	489
	Total and average	35,830	13.6	1,921	18.6	488,535	188,254	5,250	386
	Group 3. Fields with spacing of 10 to 15 acres per well								
1	Vernon	1,100	3.0	74	14.7	3,300	4,907	4,460	1,487
2	Monterey, S.	200	2.0	14	14.3	400	492	2,460	1,230
3	Deep River	820	5.1	60	13.7	4,182	10,000*	12,200	2,390
4	Overisel	2,080	3.0	155	13.4	6,240	2,635	1,265	422
5	Sherman	1,220	4.0	96	12.7	4,880	4,556	3,740	935
6	Adams	1,220	15.0	97	12.6	18,300	10,800*	8,850	590
7	Bangor, Old and New	700	1.43	56	12.5	1,000	1,275	1,820	1,270
8	Bloomingdale	3,000	4.0	246	12.2	12,000	6,354	2,118	529
9	Salem, Old	2,500	8.0	206	12.1	20,000	3,540	1,416	177
10	Buckeye, N. & S.	5,400	11.0	455	11.8	59,400	23,167	4,280	390
11	Columbia	1,230	2.5	104	11.8	3,075	2,318	1,880	750
12	Walker	5,700	6.0	494	11.5	34,200	14,381	2,520	320
13	Edenville	400	8.0	35	11.4	3,200	1,383	3,460	432
14	Salem, New	1,100	6.0	104	10.6	6,600	4,661	4,240	707
15	Diamond Springs	560	3.5	56	10.0	1,960	889	1,590	454
16	Crystal	2,180	4.0	235	9.3	8,720	7,575	3,480	870
	Total and average	29,410	6.4	2,487	11.8	187,457	98,933	3,364	526

*From *Oil & Gas Journal*, January 26, 1946.

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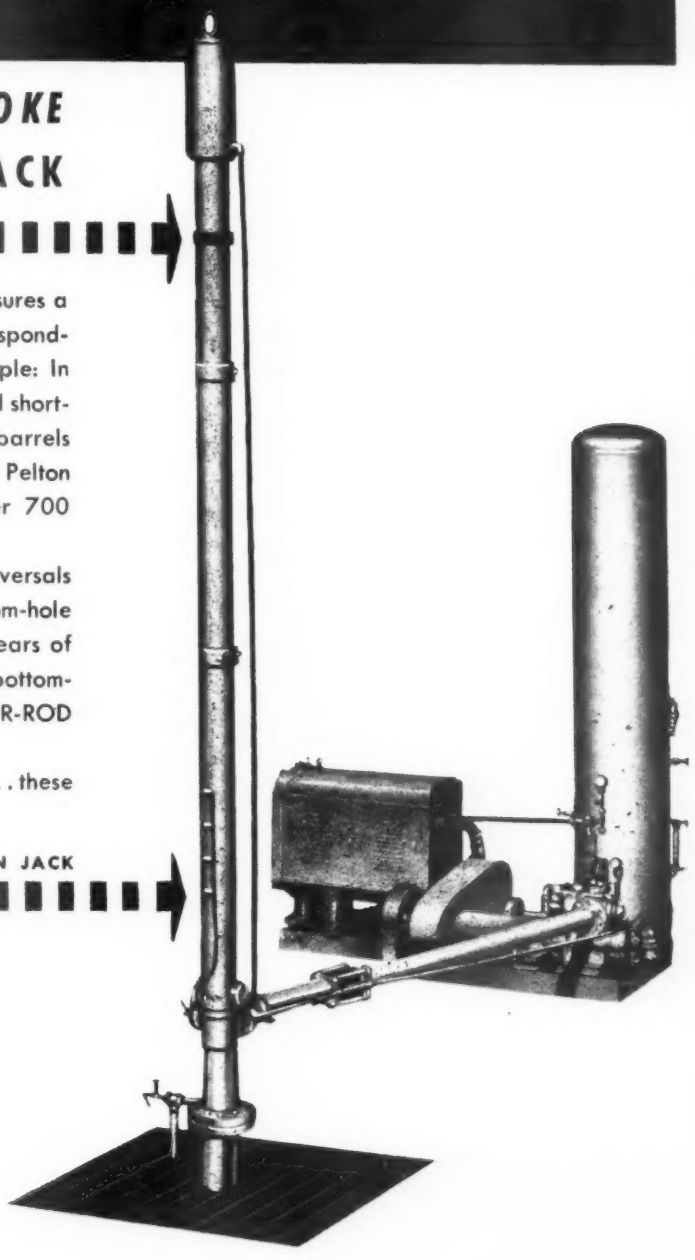

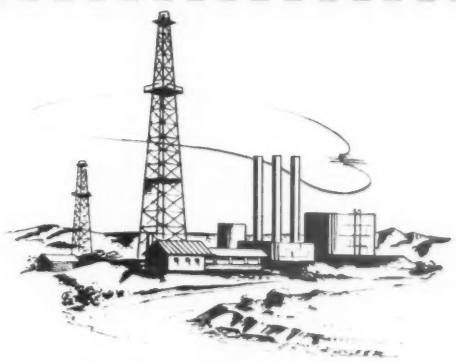

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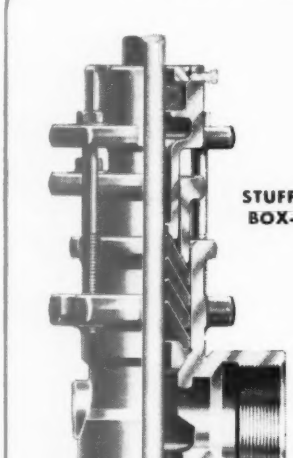

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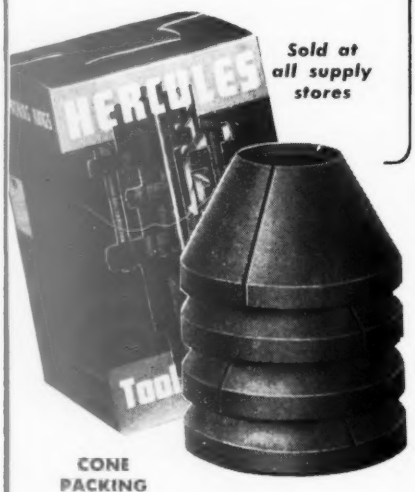

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The logarithmic chart in Fig. 1 illustrates graphically the relation between well spacing and ultimate recovery in bbl per acre-ft in these Michigan fields. Based upon these results, it appears that the closer the spacing, the higher the estimated ultimate recovery per acre-ft.

Plotting the relation of spacing vs. acre-ft recovery for each of the individual fields presents a scattered appearance, and can easily lead one to assume that spacing has no appreciable effect. Consequently, it has seemed better to average the results by groups of fields and plot the average value thus determined.

It will be noted that estimated acre-ft recoveries in some fields in group 1 are greater in the areas with considerably closer spacing. It is not surprising that such anomalies appear when considering the nature of these limestone formations and the differences in porosities and permeabilities in the various fields.

The stated thicknesses of the producing formations are not accurate but the figures are the best that can be obtained from published literature. Porosities are unobtainable from published material, though undoubtedly are erratic, and yet the factor of porosity has a greater influence on recovery than any other factor, due both to the greater oil content and to the greater permeability that usually accompanies higher porosity. As a rule, porosity greatly outweighs the effects of gravity of the oil, viscosity, connate water, or any other factor. This may be deduced by observing the relative effects of the various factors enumerated in the paper presented before the American Petroleum Institute by Craze and Buckley and published in *Production Practices* for 1945, where the divergency of offsetting characteristics makes it impossible to compare and analyze satisfactorily the relative producing capacities of individual reservoirs. It seems to the writer that a better study can be made by using an average of the individual characteristics for groups of fields than by considering each field separately.

A factor that may be of considerable importance is the daily rate at which oil is produced. Studies made of Seminole, Oklahoma City, Powell, Wortham, Luling, and other fields readily may lead one to suspect that the exceptionally high recoveries obtained in those fields may have been due partly to the high rates at which the wells were produced.

In the later life of oil fields spacing programs may be changed, extensions to fields may be made, and additional producing horizons may be discovered. The drilling of additional wells in a given zone of a field at a later date is a change to closer spacing and increased recovery may take place. This happened at Oklahoma City where wells were drilled down the flank several years after the main drilling program had been completed and resulted in increased recovery; also additional drilling within the last few years in the old and rather densely spaced Healdton field has resulted in additional ultimate recovery. It may, therefore, become necessary later to revise the estimates of ultimate recovery in several of these Michigan fields, just as has been the case in many other fields, although in Michigan fields there seems to be greater likelihood of such revisions being made upward rather than downward.

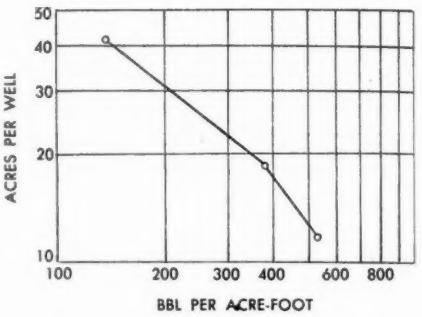

FIG. 1. Well spacing vs. acre-foot recovery in Michigan oil fields.

Definite comparisons of the results of close spacing can be made only where all other factors remain constant, and this is seldom possible. The nearest approach can be made by confining the study of a given characteristic to areas in the same field where there is greater likelihood of factors remaining constant. Studies of comparisons of given factors in different fields, because of the many divergent conditions, are likely to result in confusing the interpretations.

The necessity of revising estimates of ultimate recovery has been pointed out by K. C. Heald in *AAPG Bulletin*, No. 8, 1947, whose remarks are as follows: "The large revisions and extensions mean that it is not possible, during the year of discovery, to appraise the importance of the discovery. It is our practice to talk only of the oil that is definitely in sight, and to let future years demonstrate that the deposit was larger and richer than we could predict with assurance. Guesses will vary about how long it should take to know the real magnitude of discoveries, but all students of petroleum reserves now realize that years must elapse after the discovery before the recoverable oil in a field of real importance can be accurately estimated. They also know that every important change in price of oil, in the cost of labor, in reservoir engineering and in many minor factors, will increase or reduce the amount of oil that can be recovered from wells and fields before economic conditions force their abandonment." ★ ★ ★

Leduc reserves

Recent estimates of the new Leduc field reserves in Alberta, Canada are around 100,000,000 bbl. with strong indications of substantial increases to come. Imperial Oils, Ltd., which discovered the field, has a $20,000,000 program for drilling in the area.

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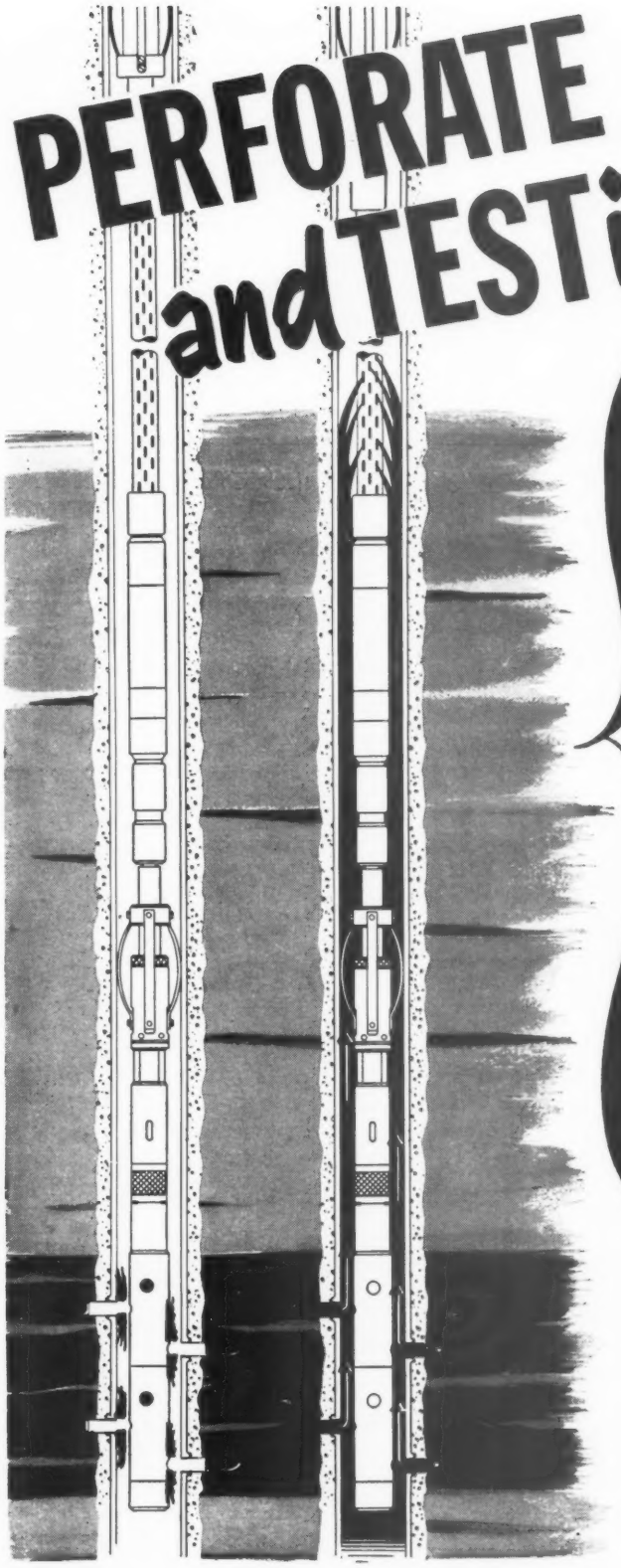

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Oil country tubular goods*

By W. F. McCONNOR, *vice president*, National Tube Company

YOUR program committee has asked me to speak to you today on the subject of "Oil Country Tubular Goods." I will endeavor to give you the factual data pertaining to this subject and with your knowledge of the producing end of the oil business, you will be in position to estimate the balance between supply and demand of tubular goods for the present and immediate future.

A review of the industry's production of oil country tubular goods, as taken from the published records of the American Iron and Steel Institute, will give us the historical pattern of past demand, upon which the pipe industry has always projected its future policies and programs. All production figures are given in net tons.

Production of oil country tubular goods—net tons:

1926	1,093,013
1927	848,068
1928	801,082
1929	837,349
1930	377,154
1931	165,928
1932	304,157
1933	366,157
1934	680,804
1935	744,076
1936	1,115,620
1937	1,418,579[1]
1938	1,034,921
1939	1,050,083
1940	1,028,410
1941	1,050,643
1942	457,603[2]
1943	674,576[2]
1944	1,126,705
1945	1,117,793
1946	1,094,962[3]
1947	1,300,000 (est.)

1. This tonnage includes 170,000 tons of lapweld oil country goods.
2. Production was restricted in this period by Government directive until all existing mill, field, and customer stocks of oil country goods were well depleted.
3. Preliminary.

The average of the 10 prewar years, 1931-1940, was 790,000 tons per year. This represents your industry's purchases in a free market where the supply of tubular goods was greater than the demand. Production of 1,095,000 tons in 1946 was 38 per cent greater than the prewar average year. An output of 1,095,000 tons in 1946 was quite high, considering the interruptions due to the steel strike in January and February of that year, and the coal strike in April and May, coupled with curtailed production due to many shortages such as scrap, coal, coke, labor, freight cars, natural gas, fuel oil, etc.

The American Iron and Steel Institute's statistics for 1947 on oil country goods will not be available until next year; however, preliminary figures for the total industry on all pipe and tubing for the first six months of 1947 are now available, showing a production of 3,000,000 tons, or at the rate of 6,000,000 tons for 1947. The preliminary figure released early this year for total industry's production of pipe and tubing for 1946 was 4,700,000 tons, which figure has now been increased to 5,000,000 tons, including year-end reporting companies. Thus, if the last half of 1947 equals the first six months' production, this year should exceed 1946 by 20 per cent. Field reports of our company's representatives indicate that total industry's shipment of oil country tubular goods has been proportionate to the pipe and tubing in the first six months of this year. Therefore, shipments of oil country goods for 1947 are going forward at the rate of 1,300,000 tons per year, or 65 per cent in excess of the average 1931-1940 year.

The following table (as assembled by a well-known national reporting agency) gives the data on new wells completed annually in the United States:

Year	Total number of new wells	Total footage of new wells	Average depth per new well, ft
1926	29,456	82,476,800	2800
1927	24,089	72,267,000	3000
1928	22,232	66,696,000	3000
1929	26,069	75,600,100	2900
1930	20,827	60,398,300	2900
1931	12,233	35,769,292	2924
1932	14,910	44,894,010	3011
1933	12,765	37,350,390	2926
1934	21,122	56,141,433	2658
1935	24,581	67,844,939	2760
1936	28,962	80,996,816	2797
1937	35,045	104,733,341	2989
1938	29,127	90,585,158	3110
1939	28,012	85,523,094	3053
1940	31,149	96,182,605	3088
1941	32,510	99,347,714	3056
1942	21,990	67,963,053	3088
1943	20,349	61,991,857	3046
1944	25,786	84,378,457	3272
1945	26,649	92,982,113	3489
1946	30,333	101,025,789	3331
First 6 mos 1947	14,546	50,388,619	3464

Previous experience indicates that in general a larger number of wells are drilled in the second half of the year than in the first half. If we extrapolate the figures on the basis of 1946, the number of wells drilled should be 32,000, involving approximately 110,000,000 ft of hole. Various estimates have been made by people in the oil industry predicting for 1947 anywhere from 32,000 to 33,500 wells, covering a range of footage from 110,000,000 to 121,000,000 ft. The average depth of well predicted for 1947 is 3600 ft. If the foregoing figures are realized in 1947, the aggregate depth of the wells will be in excess of the peak year of 1937 and considerably in excess of any other year. It is significant that with the critical demand for oil in the war period of 1942-1945, an average of 23,693 wells was drilled per year as contrasted with 30,333 new wells drilled in 1946, or an increase of 28 per cent. The average depth of wells drilled in 1946 was 8 per cent deeper than in 1942. The new wells drilled in the first six months of 1947, compared to a like period in 1946, show a further increase of 4½ per cent in number and 7.8 per cent in footage.

The high tonnage required in oil country goods has been accentuated by the nature of the demand. Casing of 80,000-lb minimum yield, which for National Tube Company was 7 per cent of the tonnage of total casing in 1942, increased to approximately 26 per cent in 1945. This added burden has been largely due to increased well depths. The first well to a depth greater than 12,000 ft was drilled in 1935, while in 1946 there were 106 such wells. In the 1942-1945 period an average of 35 wells per year of 12,000 ft and deeper was drilled, as compared with three times this number in 1946.

Within a short time after V-J Day, August, 1945, the collective demands for pipe and tubing were so greatly in excess of the available supply that some form of allocation or controlled distribution became necessary. The procedure adopted by National Tube Company was to follow as nearly as possible the principles of the Controlled Materials Plan set up by the War Production Board during the war period. Briefly, the pattern followed by us was to take the ingot tonnage available for pipe and tubing production, and allocate this tonnage into standard pipe, oil country goods, line pipe, and tubing specialties, in the same percentage proportions as obtained in a typical prewar period. The end product was then distributed geographically and by industries in as equitable a manner as possible from a historical pattern. In the case of oil country tubular goods, we were very careful to maintain the proper historical balance between large integrated oil companies and other producers.

In reviewing our allocation data, it is of interest to note that the order bookings in standard pipe and miscellaneous line pipe were of such volume after V-J Day that it was necessary to put

*Presented before the Annual Meeting of the Independent Petroleum Association of America, Oklahoma City, Oklahoma, September 30, 1947.

these classes of material on allocation by September 15, 1945, with allotments becoming effective January 1, 1946. In the case of oil country goods, the orders booked were comparatively slower in reaching a high volume. It was not until March 15, 1946, that the allocation of oil country goods was necessary, and the allotments became effective June 1, 1946. It is therefore apparent that the present unusual demand for oil country goods was not even realized or anticipated by the oil companies themselves.

In any form of allocation, it is impossible to take into account all of the many factors that might affect equitable distribution, such as population shifts, advances and retardents in certain industries, questions relating to the critical nature of certain products, etc. However, it must be recognized that any form of allotment, whether the basis may be to the advantage or disadvantage of a certain group or customer, is far superior and more equitable as a whole, than filling up order books on an unrestricted basis.

It must be kept in mind that allocations had to be tempered with the mill's ability to produce within certain size ranges, finishes, etc., and with their ability to handle and ship, physically, the allocated pattern under the unusual conditions existing during the reconversion period.

The production of drill pipe is coming much closer to the demand, particularly in the case of API drill pipe. It is apparent, however, that at the present time the pipe industry is unable to meet the immediate present requirements of the oil industry for casing and tubing. Many oil men have inquired as to the prospects of an immediate, further increase in the availability of casing and tubing. The only means by which we could effect an immediate increase in oil country goods production would be to produce less of other steel tubular products. We can see no signs of recession in the demand for other pipe and tubing major tonnage items that might permit the manufacture of some additional oil country goods.

If the demand for other steel products, such as sheets, plates, rails, etc., declines before pipe and tubing, some additional semi-finished steel might be released that could be processed into pipe with industry's present capacity, but this additional tonnage would not be large.

Major increases in steel mill capacity for an individual item such as oil country goods cannot be accomplished in a short time. It must be recognized that oil country goods account for only a portion of total steel tubular production. Much of the equipment used for the production of line pipe and standard pipe can be used for the production of oil country goods with minor changes in finishing facilities. Under ordinary circumstances, a sudden sharp increase in demand has been met by using these other facilities. Unfortunately, at present, this greatly increased demand for oil country goods is concurrent with an equally sharp increased demand for line pipe and standard pipe. Not only are these other facilities otherwise occupied, but all of the steel available for tubular production is allocated to product. Because of the very large investment required for a major program, we must analyze the overall demand over a 20-year or longer period to justify such expenditures. Present high costs of construction are not conducive to such an investment, particularly since very large sums must be spent for maintenance and replacement of existing equipment, which has been driven to its utmost over a sustained period of six years, with only emergency repairs.

The time element involved and the magnitude of the problem is well illustrated in National Tube Company's postwar program of plant rehabilitation and modernization. Immediately after V-J Day, we embarked upon a multimillion dollar project, but construction costs have increased so rapidly that the investment will be substantially in excess of the original estimate. This involves the revamping of our butt mill facilities; a complete, new modern mill warehouse for the handling of standard and miscellaneous pipe; a new coke plant; a new blooming mill, billet mill, and bar mill; additional ingot capacity covering about 30,000 tons of ingots per month, and a new seamless mill to manufacture 2-in. to 4-in. pipe. This last-named mill embodies new principles, and is a fast, high-production unit of a type that will outrank any other seamless mill we have. When this unit is in operation, it should assist greatly in supplying the present high demand for oil well tubing. After completion of this program, our capacity will be better balanced to handle the overall trade requirements, and our production will be somewhat increased.

It must be realized that new construction is hampered by many obstacles, including long deliveries of electrical equipment. Prolonged strikes in this industry, as well as volume demand, have contributed to this situation. Completion of our program was planned in 1947, but we will be most fortunate if it can be completed by the end of 1948.

I am not familiar, of course, with the detailed plans of other producers of oil country tubular goods except to state that very little increased capacity that would give more oil country goods has been definitely announced.

The pipe industry has collaborated wholeheartedly with the American Petroleum Institute since that body was formed. In the last 10 years many technological improvements have been made by the pipe industry to give the oil industry greatly improved quality of oil country goods. In the case of National Tube Company, one of the outstanding items was the development of a special grade of deoxidized Bessemer steel for use in seamless tubular goods. Several hundred thousand tons have been delivered to the oil industry and used with outstanding success. This has provided considerable oil country goods that would not have been available otherwise. We also developed a special process of producing warm-worked casing, which has enabled us to keep pace with the heavily increased requirements of N-80 casing.

Looking back just 10 years to 1937, we were supplying Grade C and Grade D API casing. These products were made to the specification of 45,000 lb and 55,000 lb minimum yield, respectively. Today, in 1947, this casing has been supplanted by grades J-55 and N-80. Despite the tremendous increase in costs in this 10-year period, casing prices have increased very little. In the J-55 grade we are supplying a material of 22 per cent higher yield point at only 11 per cent greater price than the lower yield material furnished in 1937. Referring to the N-80 casing of today, it has a 45 per cent enhancement in specification yield point over the old Grade D casing and is priced at only 15 per cent above the 1937 figure. In view of all the comments on prices carried in the national press and periodicals, we regard this as an outstanding contribution to the success of the oil business.

There have been many wild rumors and much comment regarding the quantities of oil country goods shipped in export. The Institute does not publish separate export figures for oil country goods and only lists total figures for export covering all classes of pipe. Total pipe exported in the prewar period, 1937-1940, amounted to approximately 7 per cent. The total pipe exported by Institute members in 1946 and the first four months of 1947 was practically the same percentage as in the prewar period.

The Department of Commerce likewise does not publish separate figures for oil country goods but has statistics combining oil country goods and line pipe. The Government figures are higher than the Institute figures because they include shipments by non-Institute members, shipments by Institute members to the domestic trade which have been reshipped in export, purchases from domestic jobbers' stocks for reshipment to export, etc.

Referring specifically to our company, the percentage of oil country goods exported in 1946 and the first six months of 1947 was lower than the percentage of oil country goods exported in the free market of 1939-1940 and a lower percentage than that shipped in 1944 and 1945 under Government allocation. Practically all our oil country goods shipped in export is sold to American-owned companies.

In conclusion, I would like to state that it is my feeling that both our company and the pipe and tubing industry as a whole have made a sincere and strenuous effort to supply a maximum amount of oil country tubular goods to the oil industry in the greatest period of sustained demand in the history of the United States. ★ ★ ★

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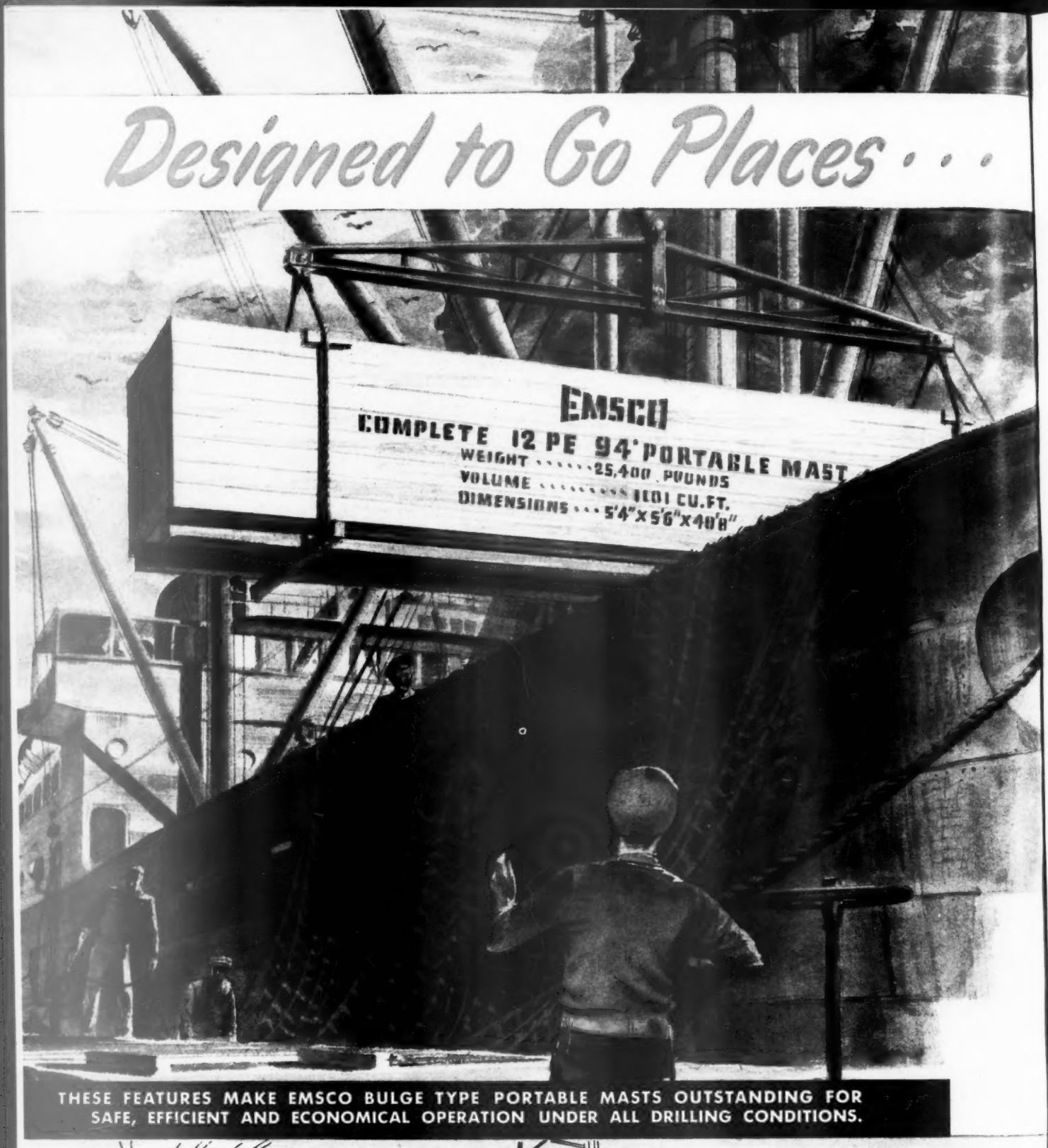

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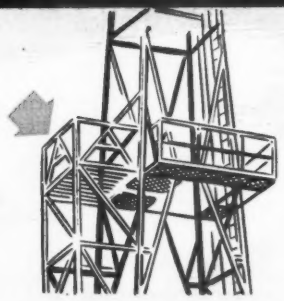

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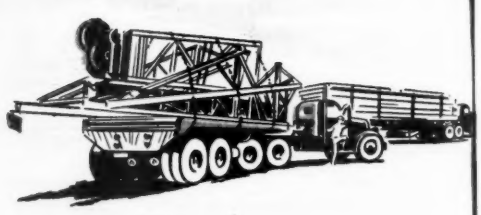

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Developments in petroleum chemistry*

By F. W. MILLER, E. I. du Pont de Nemours and Company

ALTHOUGH the manufacture of chemicals from petroleum began only about 20 years ago, it is now a mammoth industry in its own right. Today hundreds of chemicals are being made industrially from petroleum hydrocarbons and minor amounts of such elements found in petroleum as nitrogen, sulphur, and oxygen.

In 1925, less than a tenth of 1 per cent of the organic chemicals manufactured in the United States, actually about 150,000 lb, came from petroleum sources. At that time there were only a handful of chemicals derived from petroleum—actually they were isopropyl alcohol and a few chlorinated hydrocarbons. Now there are more than 5400 finished products made from petroleum and they range all the way from ash trays to Milady's silk-like garments.

In 1935, there was only one oil company classified as a chemical manufacturer. Now there are more than 50. In 1946, more than 25 per cent of all the organic chemicals manufactured, about 3.8 billion lb, were derived from petroleum or natural gas sources.

Of course, you are all familiar with the impact that the fuel shortage is having on the petroleum industry. The time doesn't seem so far off when this country will get much of its petroleum products from the conversion of natural gas. As you know, two multi-million dollar plants —in southwestern Kansas and at Brownsville, Texas—are being installed to change natural gas into synthetic petroleum products. By early 1950, 7000 to 8000 bbl of oil a day are expected to flow from the Kansas plant. Some 7000 bbl a day, chiefly gasoline, is the estimated output of the Texas plant.

These are the first two concrete steps toward the sweeping changes that are coming in the entire petroleum industry. It well may be that the next generation—perhaps even our own—will see this revolution expand to cover the whole fuel industry, not only gaseous and liquid, but solid as well.

That era is off on the horizon of the petroleum industry. But the beginning of the change-over will have a dramatic and immediate effect on the chemical industry. A revolution in production methods is already at the doorstep of many branches of chemical manufacture, and all industries that depend on chemical products will be affected.

The Texas and Kansas plants alone are expected to produce, in addition to fuels, more than 150,000,000 lb of chemical products a year. These will include an inexpensive source for many alcohols —methyl, ethyl, propyl, butyl, and amyl, which, as you know, are important solvents and chemical intermediates. Acids, too, will come from the synthesis process; for example, acetic acid, necessary for the manufacture of cellulose acetate for rayon, photographic film, and plastics, also propionic acid, from which we get our "Mycoban" mold inhibitor for bread and other baked foods. Another chemical product connected with fuel synthesis will be acetone, an industrial solvent and a raw material used by the chemical industry for the manufacture of resins such as du Pont "Lucite" acrylic resin. Still another major product will be acetaldehyde.

Coming onto the market in large amounts, they will have an important effect on prices, help to open up new fields, and lead to the development of new plastics, solvents, pharmaceuticals, and other products.

The future of the petroleum chemicals industry in the United States is indicated by the $340,000,000 investment that is being made in the installation of plants in the Texas Gulf area alone. Among these plants there are included those of the Carbide and Carbon Chemical Corporation, Celanese Corporation, Dow Chemical Company, du Pont, Monsanto, Rohm & Haas, and the Shell Chemical Company, to mention only a part of them.

As is well known to all of you, however, the work of manufacturing chemicals from petroleum raw materials is well under way and expanding rapidly. Responsible executives believe that in 1948 the synthetic chemical industry in the United States is entering on its greatest year ever, as demands for chemical materials increase steadily and point to a record high in production and sales. W. Ward Jackson of the Celanese Corporation has canvassed the 1948 outlook for the production and sales of the more basic synthetic organic chemicals. Included in this group are some that are of major interest in various phases of the du Pont company's activities—they are methanol, formaldehyde, acetone, acetic acid, acetaldehyde, and butyl alcohol. Borrowing liberally from Jackson's figures in the *Journal of Commerce* (January 7, 1948), and adding some of our own, let's look at the magnitude of production of these chemicals, and indicate the source of the du Pont company's interest in them.

One of the most important synthetic organic chemicals is methanol, used chiefly for the production of "Zerone" anti-rust anti-freeze, and for formaldehyde, as well as in smaller quantities for the production of "Lucite" acrylic resin, as we will see.

It is estimated that approximately 80,000,000 gal of this alcohol were produced in the United States in 1947 and roughly half of this was made from petroleum raw materials by a process that will be outlined shortly. Of this 80,000,000 gal, about 40 per cent went into anti-freeze and another 40 per cent into the production of formaldehyde. The remainder went into general solvent uses, synthesis, and miscellaneous applications.

It is estimated that the total methanol production in 1948 will be about 110,000,000 gal and in 1950, 140,000,000 gal. In view of these increasing requirements, the du Pont company is planning new facilities and increased production for 1948, a part of which will involve petroleum sources.

The method of producing methanol from petroleum products depends basically upon methane in natural gas. When methane is treated with steam in the presence of the proper catalyst under selected conditions, the resulting products are carbon monoxide and hydrogen, but unfortunately these two gases are obtained in a volume ratio of 1 to 3, rather than in a 2 to 1 ratio that is necessary for the catalytic synthesis of methanol. There are several possibilities for adjusting this ratio but they would take too much time to discuss here.

The great increase in demand for formaldehyde resins accounts in large part for the unprecedented demands for methanol production. The production of formaldehyde decreased from 1943 through 1946, but in 1947 it reached a new record of 540,000,000 lb. The demand for formaldehyde is so high, and the situation so tight, that several large users have gone into their own production of formaldehyde from methanol.

As was indicated earlier, formaldehyde is used in combination with urea, melamine, and phenol to make a large variety of plastic materials in tremendous volume. Naturally, the heavy demand for methanol for formaldehyde has resulted in a shortage for other uses. Those of you who are here from the colder regions may have a direct personal appreciation of this from the difficulty you have had in purchasing methanol anti-freezes.

Another important chemical made from petroleum sources and used by the du Pont company is acetone, the production of which in 1947 was about 350,-

*Presented before the California Natural Gasoline Association February 5, 1948, meeting by David H. Conklin, manager West Coast District, Petroleum Chemicals Division, E. I. du Pont de Nemours and Company.

000,000 lb. Approximately 10 per cent of the acetone produced still is made by fermentation, but the balance comes from petroleum sources, either by direct oxidation of petroleum natural gas or by treatment of propylene with water in the presence of a catalyst to form isopropanol. The latter is oxidized to form acetone, the chief chemical product made from propylene. But acetic anhydride, methyl isobutyl carbinol, and methyl isobutyl ketone are also manufactured. The latter two are used as solvents in the finishes industry to compensate for the shortage of butanol.

We use acetone in substantial quantities in two different ways: (1) As a chemical raw material, and (2) as a solvent in the synthetic textile industry, where it is used to dissolve cellulose acetate in the preparation of rayon.

Our chemical application of acetone comes by the route of adding hydrogen cyanide to it to form acetone cyanohydrin. The latter on hydrolysis and esterification produces methyl methacrylate monomer, which is then polymerized to the beautiful plastic that we all know in the form of "Lucite" acrylic resin, that you see in a hundred forms around you every day. Combs, brushes, cigarette boxes, clocks, horn buttons, instrument panels, road guides, and many other uses are familiar to all of you.

Let's now give some consideration to acetic acid, another extremely important product that is made from petroleum sources.

The acetic acid production during 1947 was about 380,000,000 lb. In spite of plant expansions that will probably boost the total annual output in 1948 by 20,000,000 lb, there is a possibility that textile demand in 1948 may make the acetic acid supply even more acute than it was in 1947.

About 75 per cent of the acetic acid produced in the United States last year was made from petroleum raw material sources, and about three-fourths of the annual production of acetic acid went into cellulose acetate and acetic anhydride. Of the remainder, about 20 per cent went into solvent esters and the remainder into chemical synthesis.

Acetic acid is made from ethylene by the addition of water in the presence of a catalyst to form ethyl alcohol. The latter is oxidized to form acetaldehyde, which on further oxidation goes to acetic acid. The acetaldehyde may be converted directly to acetic anhydride, if desired, or the acetic anhydride may be made from acetic acid by dehydration. Both processes are in commercial operation.

Our 1947 figures for the consumption of ethylene, used in the manufacture of acetic acid, etc., are not complete but they are of the same order as the 1946 figures, which show that approximately 400,000,000 lb of ethylene went into the manufacture of ethyl alcohol and 155,000,000 lb into ethylene glycol, the base for the so-called non-volatile anti-freezes. A very small but increasing factor in the ethylene market is its use in the manufacture of the relatively new plastic, polythene, the lightest of the commercial plastics. Polythene is made by the polymerization of ethylene under pressures between 10,000 and 20,000 psi, and is soft, paraffin-like, and tough. It is widely used as an electrical insulator. For example, in the television industry, coaxial cables are insulated with polythene. You may be more familiar with this tough, flexible material in the form of raincoats, shower curtains, garment bags, bowl covers, floating toys, tumblers, soap dishes, ice cube trays, and wrist watch straps.

In discussing the manufacture of acetic acid and the acid anhydride, we mentioned the production of acetaldehyde from ethylene via ethyl alcohol. If the acetaldehyde is catalytically dehydrated and hydrogenated, butyl alcohol is formed. In 1947, the production of this alcohol from all sources was about 140,000,000 lb, half of which came from petroleum sources. Normal butyl alcohol and isopropyl alcohol, made from petroleum propylene, are solvents for "Duco" lacquers. Butyl alcohol is also used in combination with phthalic anhydride to form dibutyl phthalate, a plasticizer for our nitrocellulose lacquers.

Phthalic anhydride is an essential intermediate in the manufacture of alkyd resin finishes such as "Dulux." On the West Coast, ortho-xylene fom petroleum is being oxidized to phthalic anhydride. This process was just recently put into commercial practice. The first plant is producing about 8,000,000 lb a year. Continuing demands for phthalic anhydride undoubtedly will lead to increased production because of the shortage of naphthalene from coal tar, the former basic material for this chemical.

Closely related to ortho-xylene is toluene, which is being produced in increasing quantities from petroleum sources, and is rapidly overtaking and passing the older source of supply, which again is coal tar. Our figures for 1947 are not complete but in 1946 there were 34,000,000 gal of toluene produced in the United States and 55 per cent of this was supplied by the petroleum industry. Of course, this 34,000,000 gal represents a big drop from the figure of 132,000,000 gal in 1945, but that merely reflects the end of the war because toluene is the base chemical for the manufacture of TNT. Leaving aside any consideration of wartime applications, TNT is an important ingredient of the priming mixtures used to set off du Pont's "Nitramon" blasting agent, an explosive widely used in quarrying, coal stripping, and seismic blasting. TNT, as you all know, is manufactured by the nitration of toluene in the presence of sulphuric acid.

Petroleum hydrocarbons also are being used in increasing quantities in paints and lacquers.

We have all become familiar with the popular statement that nylon is made from coal, air, and water, but it is probable that that statement will have to be modified shortly as nylon intermediates from natural gas as well as petroleum sources come into the picture. It is anticipated that before long natural gas as well as petroleum will be used in the manufacture of adipic acid and hexamethylene diamine, the two compounds that make up nylon salt. We hope to have more specific statements to make soon, about the application of petroleum products to nylon manufacture.

Dydrogen is needed to make both adipic acid and hexamethylene diamine. Natural gas is a good source of this element, and is also suitable for use as a fuel for some of the manufacturing processes.

In making the adipic acid, cyclohexane is used. At present, this is coming from a coal tar product, benzene, by the addition of hydrogen to the molecule. But cyclohexane is a naturally occurring component of petroleum, and it is expected that eventually it will play an important part in the nylon picture.

Cyclohexane constitutes from less than 1 to more than 4 per cent of the lighter distillate — the naphtha fraction — depending on the source of the crude petroleum. But it has to be separated out in relatively pure form for adipic acid manufacture.

Once the adipic acid is obtained, part of it is used in making the other half of the nylon salt combination, hexamethylene diamine. Here ammonia is required, and more hydrogen. The ammonia itself is made from nitrogen and hydrogen through a high pressure nitrogen fixation process. The hydrogen may come from either natural gas or steam, and the nitrogen from the air.

Finally the adipic acid and hexamethylene diamine are united to give the salt from which nylon yarn, bristles, and plastics are made. It is unnecessary for us to tell you anything about nylon because you are all familiar with the terrific impact that it has had on the American way of life.

In the time allotted, we have been able to outline very briefly the major points at which the natural gasoline-gas industry and the interests of chemical manufacturers coincide. Considering the wide variety of products we make, there are obviously many other points of contact, not the least of which is the fact that we manufacture numerous chemicals that are used to enhance the utility of petroleum automotive products. The brief outline we have given, however, is a strong indication of what the future holds in the direction of a greater community of interest between the petroleum and chemical industries. ★ ★ ★

Baytown plant expands

Humble Oil and Refining Company expects to launch a $19,000,000 expansion program this year at its Baytown, Texas, plant, according to Harry C. Wiess, president.

Already one of the world's largest refineries, an increase of 45,000 bbl. crude oil throughput will be possible when the new pipe still is completed. A new unit for making more lubricating oils is almost ready for operation.

Puymaurin No. 1 in France, the first well in Eastern Hemisphere drilled below 13,000 ft, it is said.

Deepest well in Europe

By E. BERNADAC* and E. D. LYNTON†

EXCLUSIVE

When on November 27, 1947, Regie Autonome des Petroles No. 1 Puymaurin well, situated a few miles from l'Isle en Dodon in the Department of Haute-Garonne, France, reached a depth of 13,268 ft, it was the first well drilled below 13,000 ft outside America, so far as is known to the writers. Only four other wells in Europe have approached this depth. These wells are:

Chitorant No. 1, drilled by the Crédit Minier in 1934 in Roumania. This well reached a depth of 11,755 ft.

Holstein No. 4, drilled to the depth of 12,724 ft in Germany in 1938.

A well drilled in the Baku field, U.S.S.R., in 1946 to a depth of 12,806 ft.

Plagne No. 3, now being drilled by the Regie Autonome des Petroles at 11,483 ft.

In addition to Puymaurin No. 1 and Plagne No. 3, the Regie Autonome des Petroles have drilled Aurignac No. 2, Richou No. 1, Saint Martory No. 2, and Proupiary No. 2 to better than 9,600 ft.

The drilling of Puymaurin No. 1 well is considered quite a notable achievement because of the old drilling equipment available in France. Part of the equipment is of American manufacture, and was received in 1939. The rest is of French and German manufacture, which was made available to the company in 1945. The equipment consisted of the following:

1. Two electric motors of 150 hp each, driving the drawworks and a mud pump.
2. One standby 220-hp diesel for use in case of failure of electricity.
3. One 240-hp motor on a second mud pump.

Capacity of the derrick is 150 tons and its height 122 ft.

This type of material is normally used in United States for wells not exceeding 7500 to 8000 ft in depth.

Puymaurin No. 1 was spudded on September 29, 1945. In March, 1947, it reached a depth of 12,001 ft. Diameter of hole was 8½ in. Drilling was then discontinued pending receipt of special drill pipe from the United States as similar drill pipe available in France did not provide the necessary safety factors.

Drilling was resumed on October 14, 1947, at 12,001 ft and continued until November 27, 1947, when the total depth of 13,268 ft was reached.

The well is remarkably vertical. Surveys have shown that from the surface to 5906 ft the well was never more than one degree off vertical. Some difficult operating problems were encountered;

*Technical manager, Regie Autonome des Petroles, St. Gaudens, France.
†Oil consultant, Institu du Petrole, Paris. Lynton revised and translated the original article.

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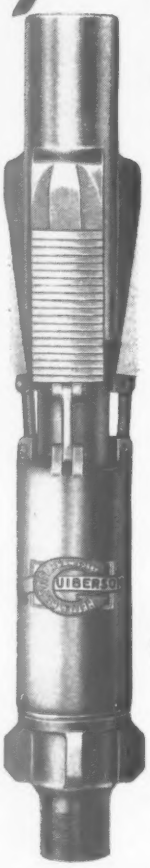

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French drilling crew at well site. Standing at back are Munsch, Dapp, and Le Parc; in foreground Ferbach (sitting), Engineer Cendre (with beret), and Morange.

for example, in the running of 9⅝-in. casing to a depth of 8203 ft, the weight of which equaled the capacity of the derrick, normally 150 tons, and also in cementing the 6⅝-in. casing at 11,988 ft, which weighed some 150 tons. Twenty-three tons of cement were used on this last job.

The high temperatures prevailing at the bottom of the well made it necessary to manufacture in France a special cement, for ordinary cement sets too rapidly at this temperature. Also, because of the high temperature encountered, the company's laboratory developed a starch based drilling mud for use in the well below 12,000 ft and this mud gave remarkably good results. In addition to these difficulties, cavernous formation were encountered below 12,500 ft, causing a total loss of circulation during drilling operations that made drilling dangerous at this great depth. This was overcome by changing the characteristics of the mud until circulation could be established again. It is estimated that during the drilling of this cavernous zone more than 700 bbl of drilling fluid were lost in the formation.

The drilling operations at Puymaurin No. 1 were carried on entirely by French crews under the direction of French engineers. The drillers were trained at the drilling school established at St. Marcet by the Regie Autonome des Petroles. This school was established in 1944 and to date some 30 drillers have qualified to drill deep wells. Credit for drilling the deepest well in Europe is given to Mr. J. de Vries, general manager, and Mr. E. Bernadac, technical manager.

The drilling superintendent was Mr. Mothre, Mr. Dapp was tool pusher, and there were three drillers, Messrs Ferbach, Munsch, and Le Parc. Engineers were Messrs. Le Polles and Cendre. The mud engineer was Mr. Thomas. The president of the Regie Autonome des Petroles is Mr. Moch.

Though Puymaurin No. 1 did not reach the depth of the Superior Oil Company's 51-11 Weller in Oklahoma of 17,825 ft, it is nevertheless an excellent piece of work in view of the fact that the material used was very old and not really suitable for such a depth. For this accomplishment, the French personnel must be congratulated for overcoming great difficulties in the drilling of the deepest well in Europe. In addition, the drilling of deep wells in France is comparatively a new industry, and these men did not have the background of many years' experience as is found in the operating departments of oil companies in the United States, who have better and newer material with which to work, and the availability of spare parts whenever needed. ★★★

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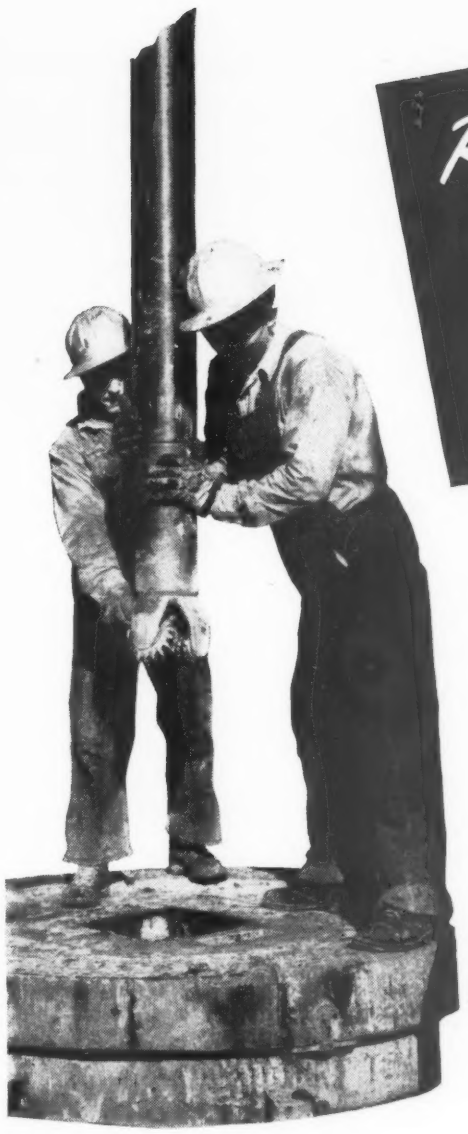

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Temperature gradients in gas lift wells

By RICHARD E. POWERS* and BENJAMIN C. CRAFT†

EXCLUSIVE

DURING the last three years increasing use has been made of thermometric measurements to solve drilling and production problems.

The applications of temperature surveys have been described by Millikan[1], Guyod[2], Farris[3], Dale[4], Nichols[5], Abadie[6], and others. As pointed out by these authors, some of the recent practical applications have been the location of permeable strata in the productive zone, gas-oil contact, source of water, fill up of cement behind the casing, point of circulation loss, and location of casing leaks.

Temperature surveys in gas lift wells have a number of practical applications. They could be used as a substitute for pressure surveys in determining what flow valves are open to production or point of gas entry and to locate leaks in the tubing; to explain increased paraffin deposition in the flow string, as a result of a change in the flowing gradient, either near the surface at the point of injection; and to serve as a guide in calculating the energy of expansion.

A Humble type sub-surface recording thermometer was used in this work. Two wells in the University field were selected for illustration, one of which was operating with three flow valves and the other with eight. The injected gas was being intermitted into the annular space every 14 min on the first well and every 10 min on the second, the length of each intermit being 1½ min. Both wells were operating with pressure opening flow valves, the upper valve on each being set for 500 psi pressure with a 25 psi decrease for each succeeding lower valve on the three-valve well and 15 psi decrease on the eight-valve well. Recordings were made at intermediate points between valves and 5 ft above each valve. The recording time at each point was about twice the period of the intermit cycle of the well.

The first survey on well No. 1 is shown in Fig.1. There are three distinct gradients, one above the second valve, one between the second and third valves, and one below the third valve. The first two are due to the injected gas at valves two and three, and the third is the normal flowing geothermal gradient.

According to the well records, valve two was placed at 1998 ft, and the instrument was stopped at 1992 ft, but the temperature recorded fell on the gradient for valve three, indicating that this station was below valve two. A second survey was run at a later date with additional measurements taken at 1870, 1925, and 1955 ft. Fig. 2 shows the results of this survey and indicates that the valve position is between 1955 ft and 1992 ft, or an error in measurement of about one joint of tubing.

There is some variation in the gradients of the two figures, which is attributed to operating conditions. On the first

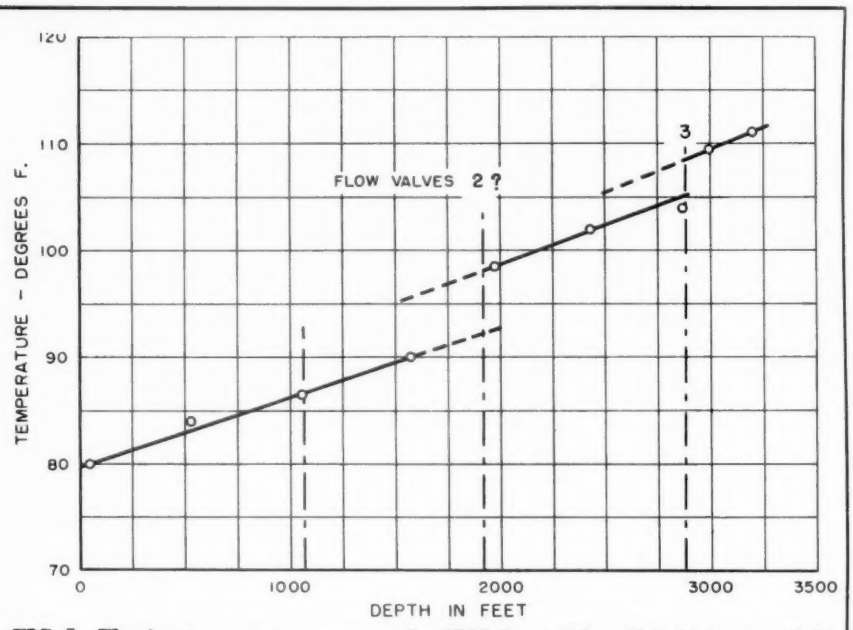


FIG. 1. Flowing temperature survey of a 6500-ft gas lift well in University field.

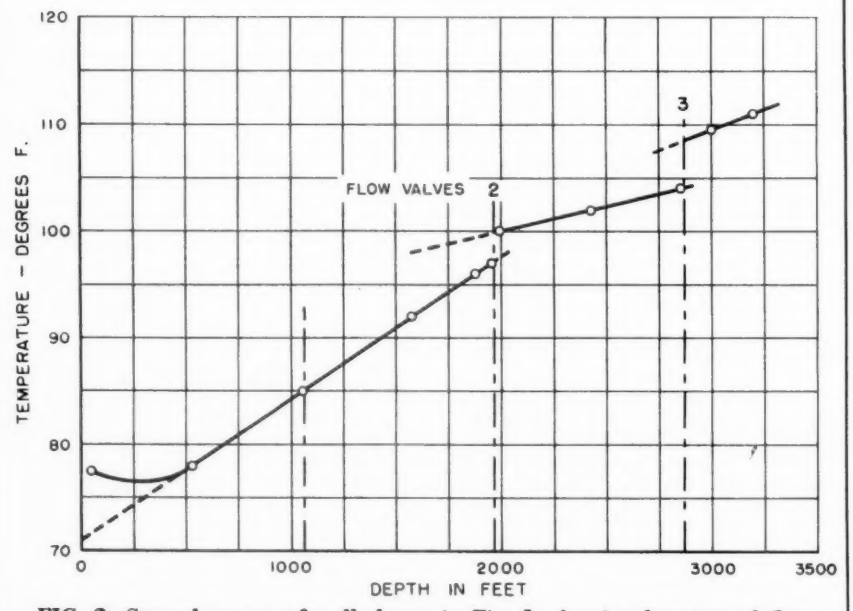
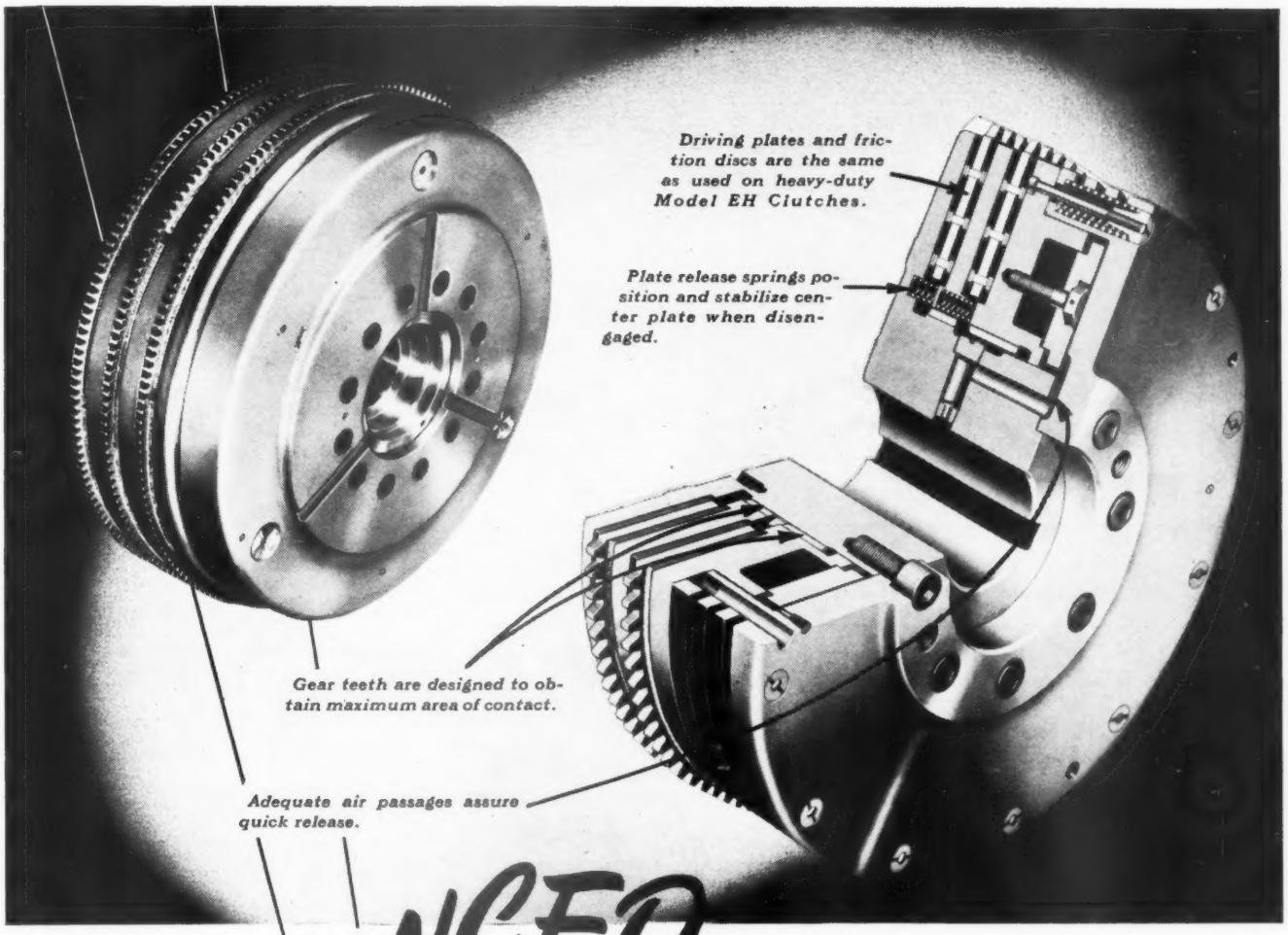


FIG. 2. Second survey of well shown in Fig. 1, showing location of flow valve No. 2 and effect of gas injected at casinghead on the flowing gradient.

*Arkansas Fuel Oil Company, Shreveport, Louisiana.
†Louisiana State University, Baton Rouge, Louisiana.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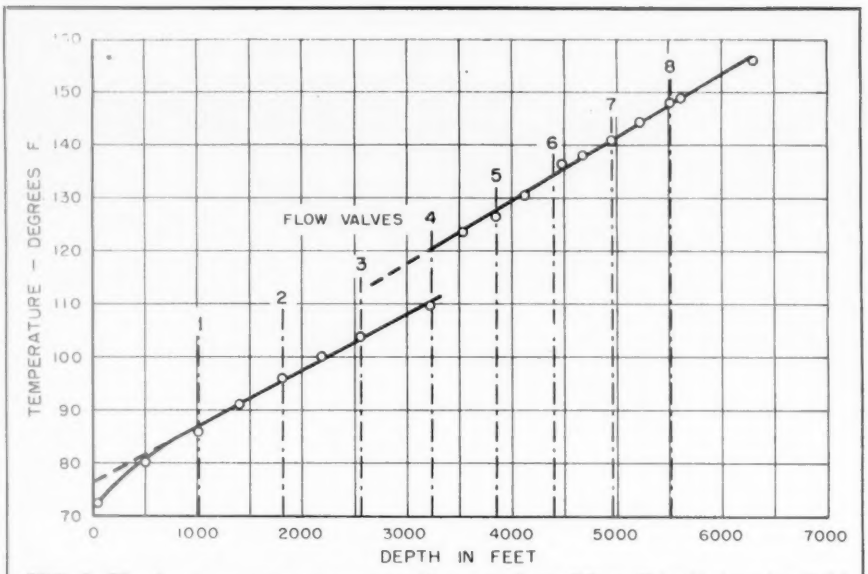

FIG. 3. Flowing temperature survey of a second gas lift well in University field.

survey the casing pressure ranged from 100 to 450 psi and the temperature was 79 F, whereas during the second survey the injection temperature was 89 F, which resulted in a high reading at 50 ft.

The measurements recorded in the second well are illustrated in Fig. 3. There are two gradients in the flow stream, the first being at valve four, indicating the point of gas injection. This caused a drop in temperature of about 10 F at this point. As in Fig. 2, the temperature at 50 ft does not fall on the normal flowing gradient. The injected gas temperature was 68 F, which had a considerable cooling effect on the flow stream.

From these results it can be concluded that temperature surveys can be used to find the point of gas injection. They can be used to show that wells producing by gas lift would be expected to have increased paraffin precipitation. One Gulf Coast operator has found it necessary to heat the injected gas to prevent paraffin deposition.

As the expansion does not take place at constant temperature, as would be true for isothermal expansion, nor does all the heat energy necessary for expansion come from the gas, as is necessary in adlabatic expansion, then a combination of isothermal and adiabatic conditions exists. This has been called polytropic by Boatright[7].

The authors wish to thank the Grubb and Hawkins Oil Company for the use of its wells and R. F. Nichols of this company for his help in running the equipment.

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By CHESTER H. LUNDT* and FRANK O. STIVERS†
Humble Pipe Line Company

EXCLUSIVE

HUMBLE PIPE LINE COMPANY'S 8-in. product pipe line from Baytown, Texas, to the Irving terminal in the Dallas-Fort Worth area has been handling four grades of gasoline since the early part of 1947; however, the late delivery of special equipment delayed completion of the permanent stations at Baytown and Hearne.

Baytown station is now ready for operation and Hearne will be completed in the near future. In addition to the two main line pumping stations, terminals or delivery points are provided near Houston, Waco, Irving, and at the pumping station at Hearne.

The present line pumping capacity between Baytown and Hearne is approximately 17,000 bbl a day. The full capacity of the equipment installed at Baytown and Hearne is approximately 30,000 bbl a day, which might be utilized with the construction of additional pumping stations.

Station design includes modern control equipment that makes the operation semi-automatic. Special features incorporate such items as pressure controllers, automatic pump venting, and motor operation of valves in controlled starting and stopping sequence. One feature not customarily included in pump stations of similar design is the use of pump and motor temperature recording instruments of the thermocouple type, which provide alarm and shutdown functions. Another feature is the use of a velocity check valve in pressure gauge lines, which prevents the spraying of gasoline in hazardous areas if a gauge or gauge line breaks.

Pump station buildings are steel roofed with brick and stone exteriors and tile and terrazzo floor interiors. The pump room is maintained under slight air vacuum and the control room, where electrical equipment is situated, is under slight air pressure. These two rooms are separated by a sealed, wire-reinforced glass partition and are considered as hazardous and non-hazardous sections of the building.

In the control room, overlooking the pump room, is the central control point for station operation where a lucite topped desk shows a schematic layout of the station piping and equipment. Lights on the desk indicate the positions of valves and diversion of flow within the station piping. It is at the control desk that main pumping units are started and stopped, and pressures, temperatures, and flow rates either indicated or recorded.

To provide remote and semi-automatic switching of products into the main line at Baytown, a dual suction system is used along with two motor-operated valves that may be opened or closed from push buttons on the control desk in the station building. This method allows arrangement of tank and manifold lines prior to the actual switching operation.

Station prime movers consist of four-stage, double volute, centrifugal pumps, which are operated two in series at the two stations to provide maximum discharge pressure of 1100 psi. Direct-connected, explosion-proof motors of 400 hp operating at 3600 rpm are used to drive the pumps.

Vertical type motor-driven centrifugal pumps are installed at each tank at Baytown to make possible the operation of the main units with positive suction pressures and allow the use of meters and strainers at low pressure.

A typical terminal installation includes two types of filtering units, and a complete metering plant with meter prover tank and the necessary auxiliaries. Meters at the terminals and stations are of the rotating vane, positive displacement type with automatic temperature compensation and ticket printing registers.

● **Station equipment, Baytown.** *Pumps and motors.* In the pump room at Baytown station are three 4-stage centrifugal pumping units with 400-hp, 2300-volt, 60-cycle, 3-phase explosion-proof motors. These units are designed to operate either singularly or two in series to provide an estimated 1100-psi line pressure. Actual pressures are determined by the cuts on the impellers, and the gravity and quantity of the fluid being pumped. Each pumping unit is provided with a motor-operated suction valve and motor-operated discharge valve piped directly from an 8-in. header in the pump room proper. A start-stop push button station is provided on the

*Assistant Chief Engineer.
†Senior Mechanical Engineer.

control desk for operation of each individual unit. In referring to a unit in this case, the motor along with its suction and discharge valves is considered a pump unit, and is actually tied into a complete sequence of starting. Several pressure switches and thermocouples at various points provide protective features for the individual pumping units. These are described later in this article. When the operator presses the start button for a particular unit, the motor-operated suction valve begins to open and completes its opening in 30 sec. When this valve reaches its full open position, an auxiliary contact initiates the starting of the unit pump motor. When the run breaker closes, the motor-operated discharge valve begins to open, and is completely open in 90 sec. In the event the discharge valve is not in a closed position the unit will not begin starting sequence. If for any reason the sequence of starting a unit is interrupted the motor-operated valves will return to closed positions after termination of the sequence time and provided power is available. Explosion-proof push button stations in the pump room near each pumping unit have two buttons marked "Stop" and "Reset", which are wired so that following action will occur:

1. When the unit is pumping and upon pressing the stop button, the unit will be shut down and suction and discharge valves closed immediately, and the entire unit rendered incapable of performing starting sequence.

2. When the unit is not operating pressing the stop button will render the unit incapable of performing the starting sequence.

3. Pressing the reset button will restore all circuits so that normal unit operations can be resumed.

Pressure protection. The individual pump units are prevented from starting if sufficient suction pressure is not available by the time the motor-operated suction valve is in its full open position. This protection is obtained by use of a pressure switch that is set at 25 psi or other desired minimum pressure. This switch is used both for the lockout feature and shutdown feature in regard to unit operation and will either shut the unit down or prevent its starting when suction pressure is less than 25 psi. Operation of either protective function sounds the station alarm and lights a red indicating light on the control desk for the particular function. Pressure switches are mounted within a covered rack on pump room wall below control desk. Units No. 2 and No. 3 are also provided with pressure switches to provide shutdown and alarm and light indication for pressures on the pump case in excess of 1200 psi.

Temperature protection. Mounted on the vertical section of the control desk is a recording pyrometer for each of the main line pumping units. Within the pyrometer are devices for recording temperatures at points as listed below and providing supplementary functions as described later.

Location	No. 1 unit	No. 2 unit	No. 3 unit
Pump bearing (outboard)	PB No. 11	PB No. 21	PB No. 31
Pump gland (outboard)	PG No. 12	PG No. 22	PG No. 32
Pump case	PC No. 13	PC No. 23	PC No. 33
Pump gland (inboard)	PG No. 14	PG No. 24	PG No. 34
Pump bearing (inboard)	PB No. 15	PB No. 25	PB No. 35
Motor bearing (inboard)	MB No. 16	MB No. 26	MB No. 36
Motor winding	MW No. 17	MW No. 27	MW No. 37
Motor winding	MW No. 18	MW No. 28	MW No. 38
Motor bearing (outboard)	MB No. 19	MB No. 29	MB No. 39

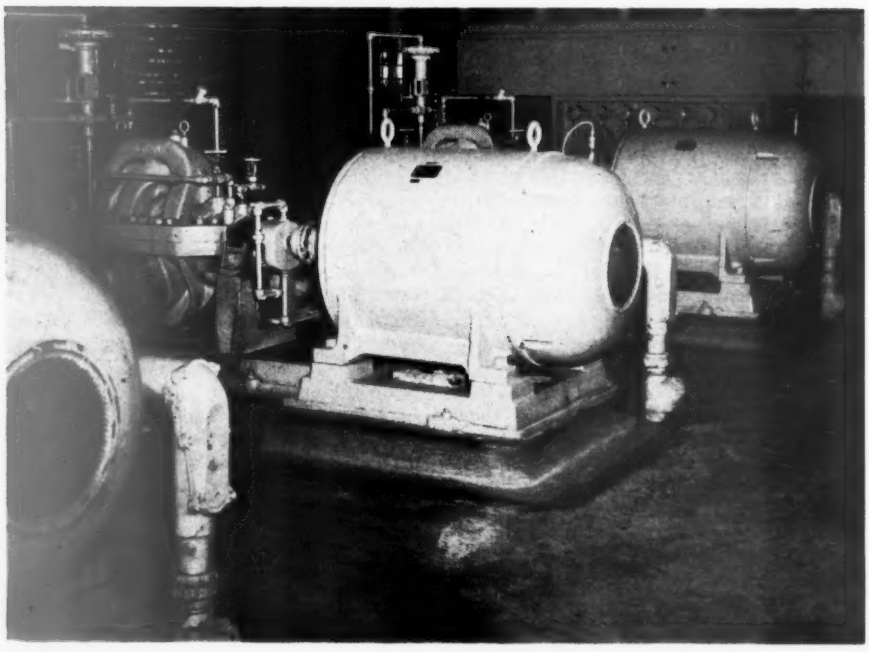
The recording pyrometer automatically moves from one point to the next, recording the temperature at each of the points throughout a complete cycle. Twelve point recorders are used and complete a cycle in 48 sec, or 4 sec between each thermocouple point. As only nine points are checked on each pumping unit the three spare points on the pyrometer are used for recording and rechecking the pump case temperature at 12-sec intervals instead of the 48 sec required for a complete cycle. This is done by proper arrangement of contacts within the pyrometer and gives a sequence and print-wheel numbering as follows: 11, 12, 13, 14, 15, 13, 16, 17, 13, 18, 19, 13.

By referring to the legend of point numbers it will be seen that point No. 13 is the point for case temperature on the No. 1 unit. Four switches within the instrument are used to make contact at different maximum allowable temperatures. In other words, if the maximum allowable temperature on pump bearings is 160 F, then one of these temperature switches is set for 160 F and makes contact to complete a circuit if either bearing exceeds that temperature. A latch-in type relay is used to sound the station alarm and show the proper indicating light for the pump bearings on the respective units. Indicating lights for each unit show when the pyrometer has operated for: (1) Pump bearings; (2) pump glands; (3) pump case; (4) motor windings, and (5) motor bearings.

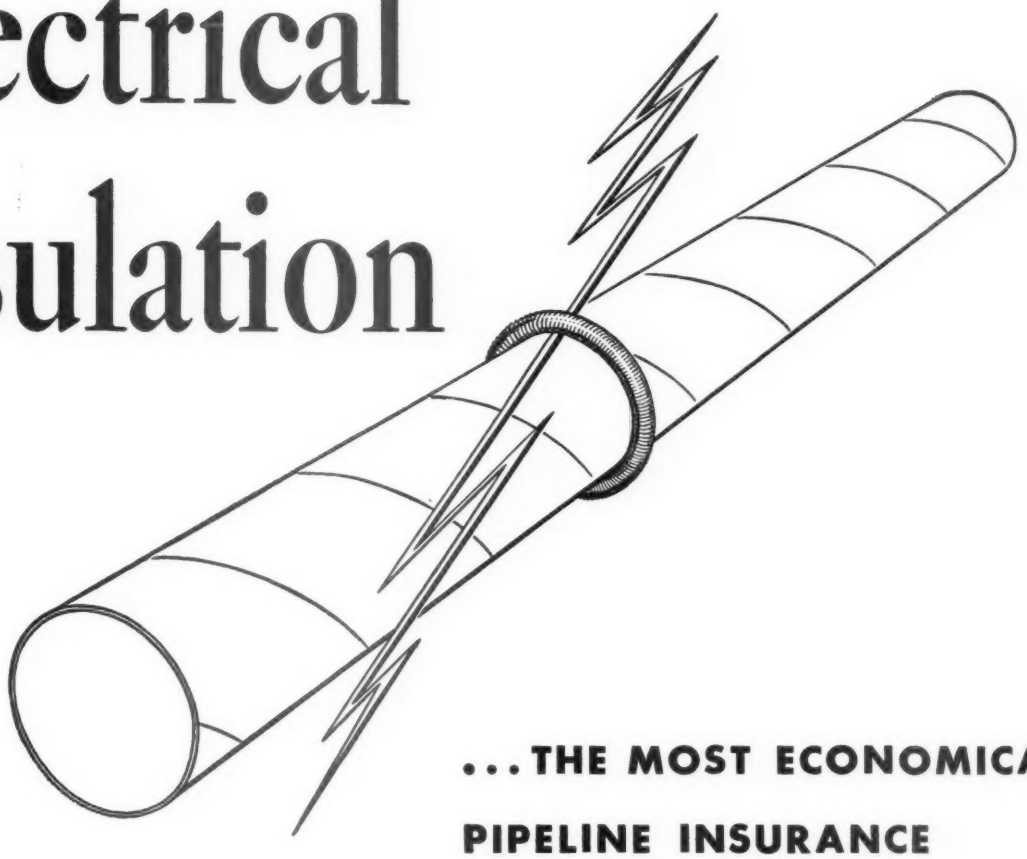
Excessive temperature at any of the points except motor windings will shut the pumping unit down, sound the station alarm, and light the proper indicating light on the control desk. Excessive motor winding temperature will sound the station alarm and light the indicating light only. Starting sequence cannot be initiated and the pump unit will not operate unless the pyrometer is manually placed in operation by the operator. The action of the pyrometer for a critical temperature condition is such that it offers a closed circuit only momentarily and then proceeds to the next thermocouple point. This momentary circuit is remade on each cycle so long as the temperature of the thermocouple point is above the critical setting (48 sec except for case temperature which is 12 sec). A hold-in time delay device is energized by the momentary circuit and is maintained just long enough to enable the pyrometer to return to the critical temperature point tested during the previous cycle. The time delay device is re-energized on succeeding cycles until temperature falls below a critical point. A 55-sec delay is used for all points.

Automatic vent system. Each main line pump unit is equipped with an automatic venting system. The vent system consists of a vent line from the pump in which is an air-operated valve and also a manually operated needle valve used for restricting flow of vented liquid. The air-operated valve uses air to close and is of the full open, full closed type. A solenoid valve in the air line to the diaphram valve is energized to open and thus maintains vent diaphragm valve in closed position when

The 400-hp motors that drive the four-stage, double volute, centrifugal pumps. Photograph was taken before terazzo floors were laid.



Electrical Insulation



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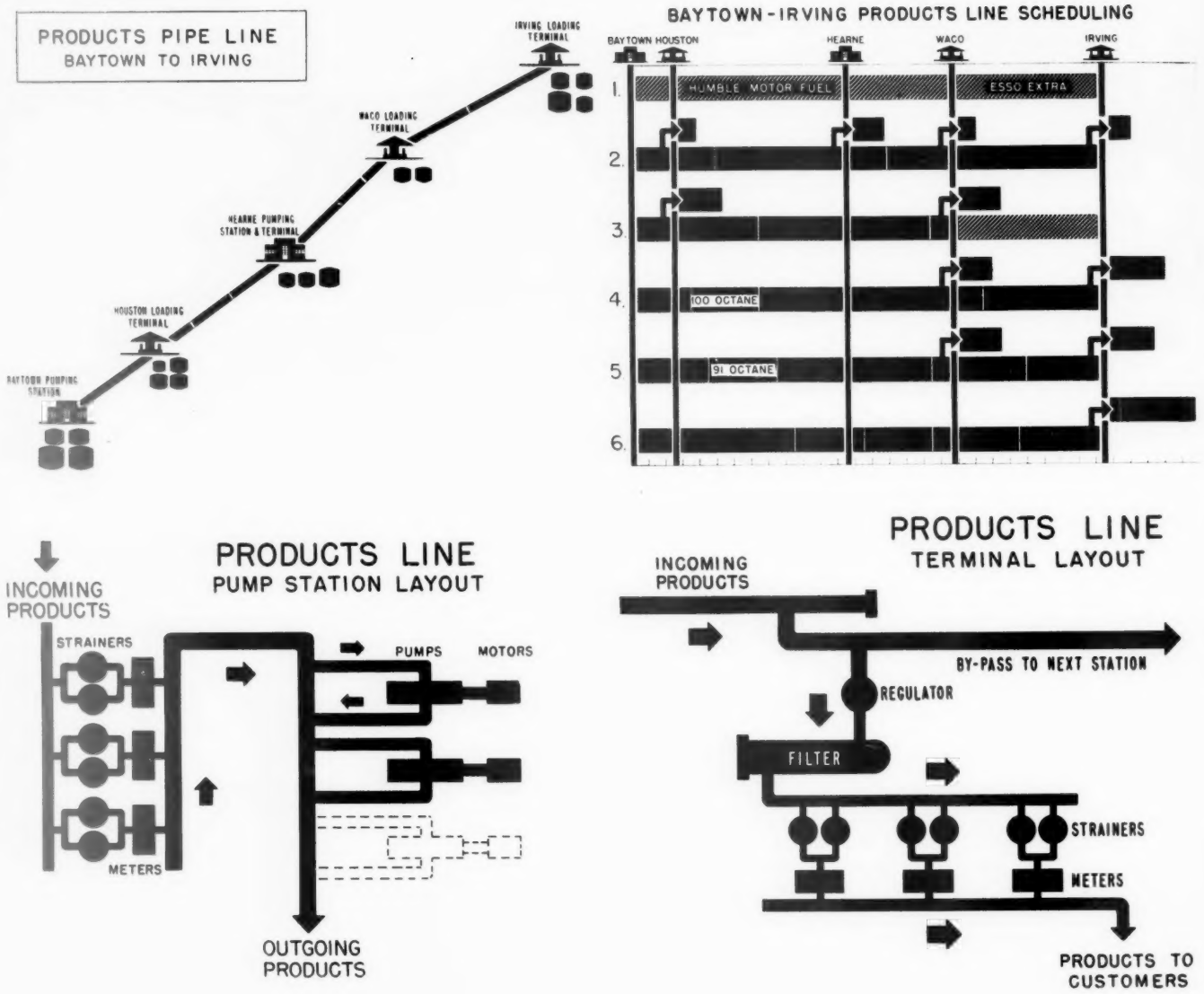


energized. The solenoid is energized from the full open position of motor-operated discharge valve such that the pump is vented at all times that the discharge valve is away from full open position. The vent system installed in this manner provides the following desirable functions:

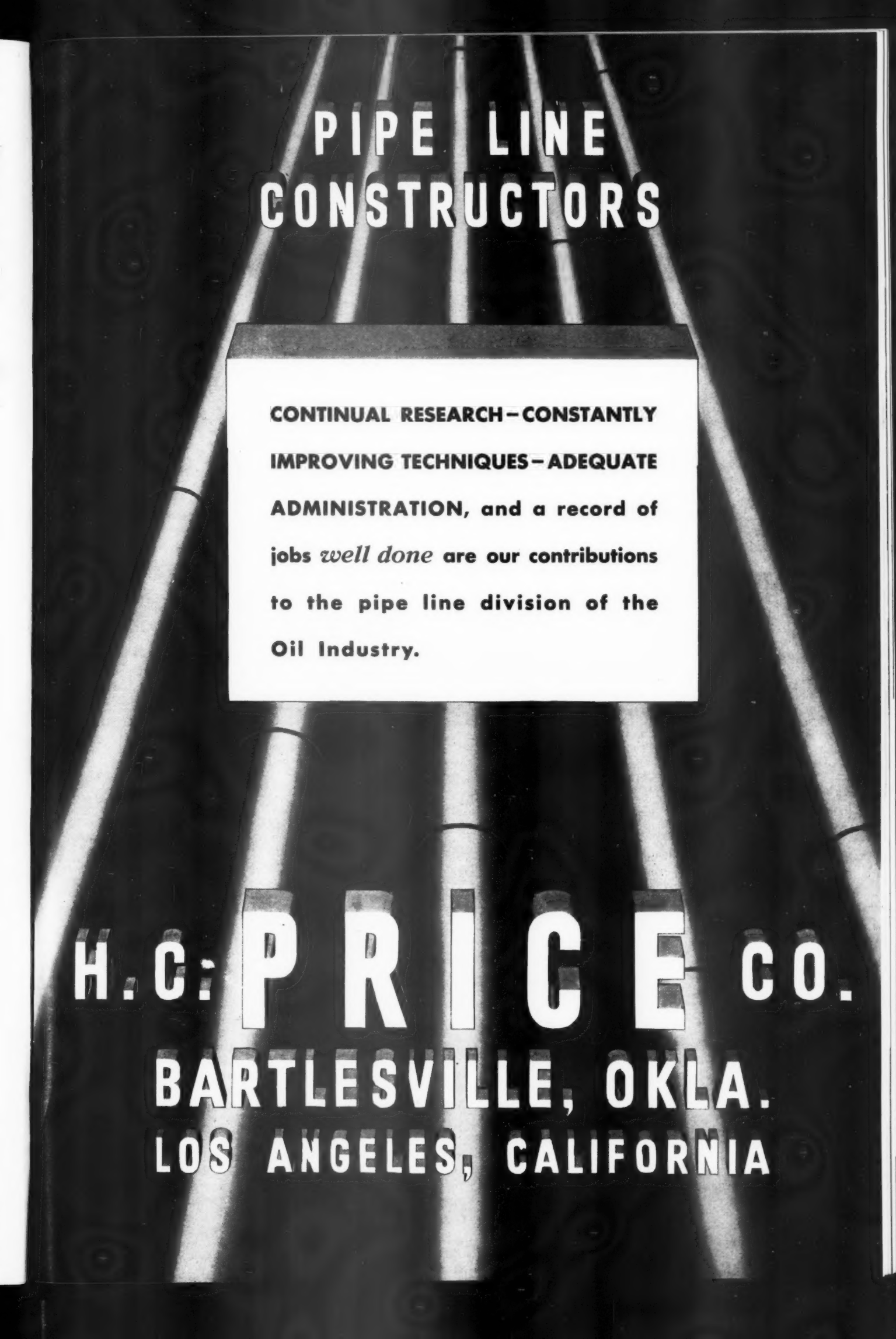
1. Pressure will be relieved and vented at all times that the unit is shut down and the discharge valve closed.
2. Any air trapped in the suction lines or pump will be expelled during starting.
3. If the discharge valve fails to open, the vent will provide a slight flow and protect the pump against vapor locking.

Pressure controllers and diaphram valve. In the pump station on the outgoing discharge line is installed an air-operated diaphram valve, which is of the normally closed air-to-open type, with an auxiliary hand wheel for manual operation. Air to this valve is controlled by two pressure controllers connected in series and mounted on the vertical section of the operator's control desk. One pressure controller is connected to the pump station suction pressure, and is known as the suction pressure controller. The other controller is connected to the station discharge and is known as the discharge pressure controller. The operation of these two instruments in series is such that the instruments in operation will reduce the air pressure to the diaphram valve and thereby control its position as determined either by the station suction pressure or the station discharge pressure. The operator is able to select a minimum station suction pressure and/or a maximum station discharge pressure for smooth operation of the station. This is done by the operator's turning a knob in the instrument and changing the control point setting of either suction or discharge pressure. The two pressure controllers are recording instruments and show pessures at the station suction and on both sides of the control valve.

Line discharge pressure switch. Connected to the station discharge line is a pressure switch that protects the line against excessive pressure by shutting down the main line units. Main line units are arranged with a sequence and time delay device such that the unit closest to the station discharge will shut down immediately, and if in several seconds (5 to 45) the line pressure is not lowered the other operating unit, if any, will shut down. The station alarm and an indicating light on the control desk will attract the operator's attention and show that the particular device has functioned.

Sump tank level switch. A liquid level switch on the sump tank, on high level, sounds the station alarm, and an indicating light shows that the device has functioned. The station alarm can be stopped by its reset button, but the indicating light will remain on until the liquid level switch trips on low level. Low level will also shut down the sump pump motor, but high level will not automatically start the sump pump.

Station alarm system. The station alarm system consists of an outdoor explosion-proof siren placed on the outside of the pump room wall over the meter slab. Also included is a flashing red light mounted on the pump room wall above the control desk. An alarm reset on control desk may be used to silence the siren and extinguish the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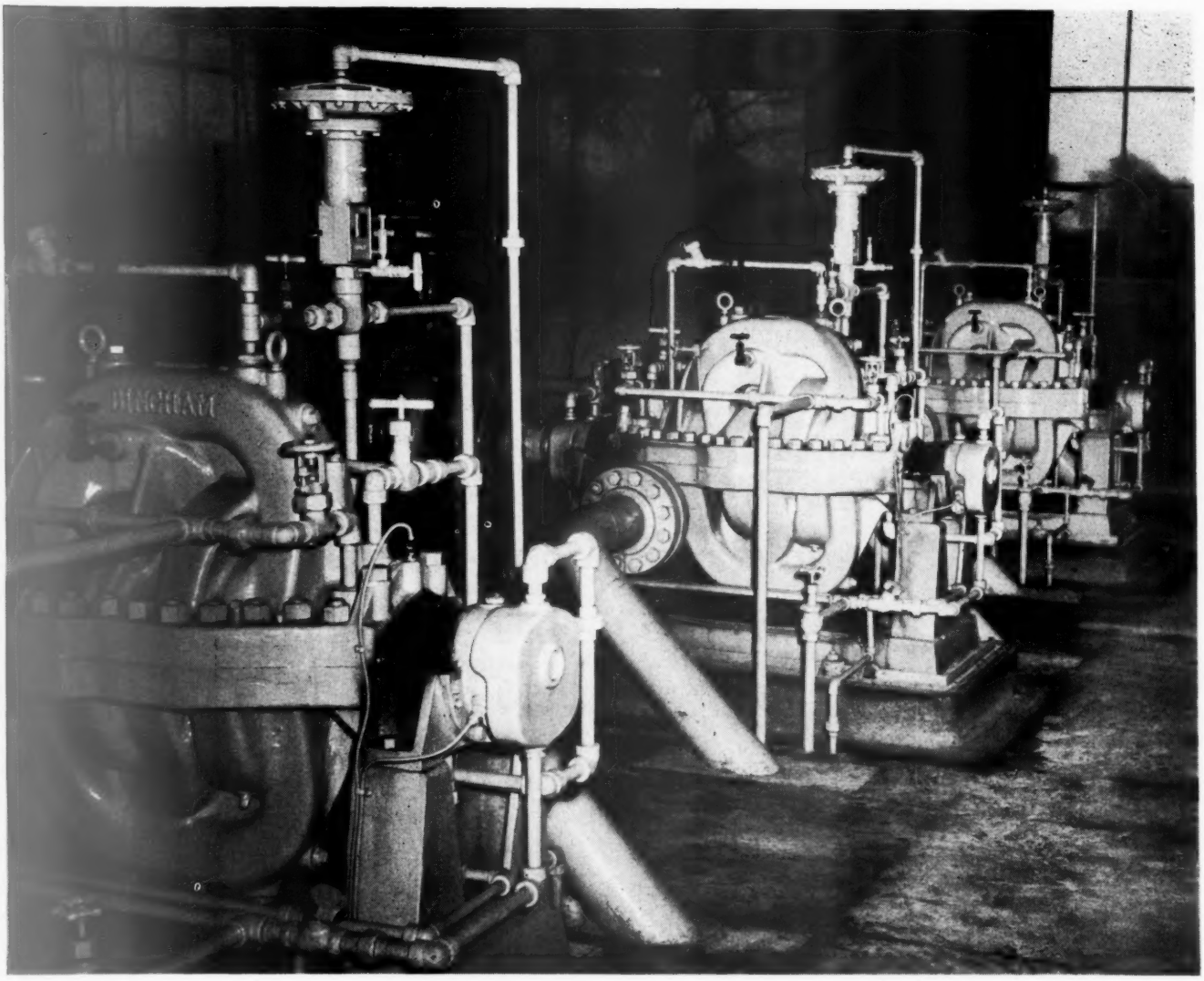


Pumping equipment consists of four-stage, double volute, centrifugal pumps driven by 400-hp motors operating at 3600 rpm. Terazzo floors were not laid when photo was taken.

flashing light, but does not affect any indicating lights on control desk. After resetting the alarm and the flashing light these two signals are ready for reuse by any other actuating circuits.

Emergency shutdown system. Mounted on the horizontal section of the control desk is an explosion-proof push button that may be used to trip the station outdoor main incoming power breaker in the event explosive vapors enter the control room. When this breaker is tripped, all power to the station and tank farm is cut off with the exception of tank farm lights and selected explosion-proof circuits. These circuits include the following:

Single phase, 110-volt: All explosion-proof lights in the control room, switchgear room, toilet, work room, pump room, meter slab, tank farm lights.

Three phase, 220-volt: Two explosion-proof exhaust blowers in pump room. One explosion-proof blower in office section of building.

Explosion-proof switches and starters for these items are installed on the wall behind the switchgear. Heating units are not included in explosion-proof circuits.

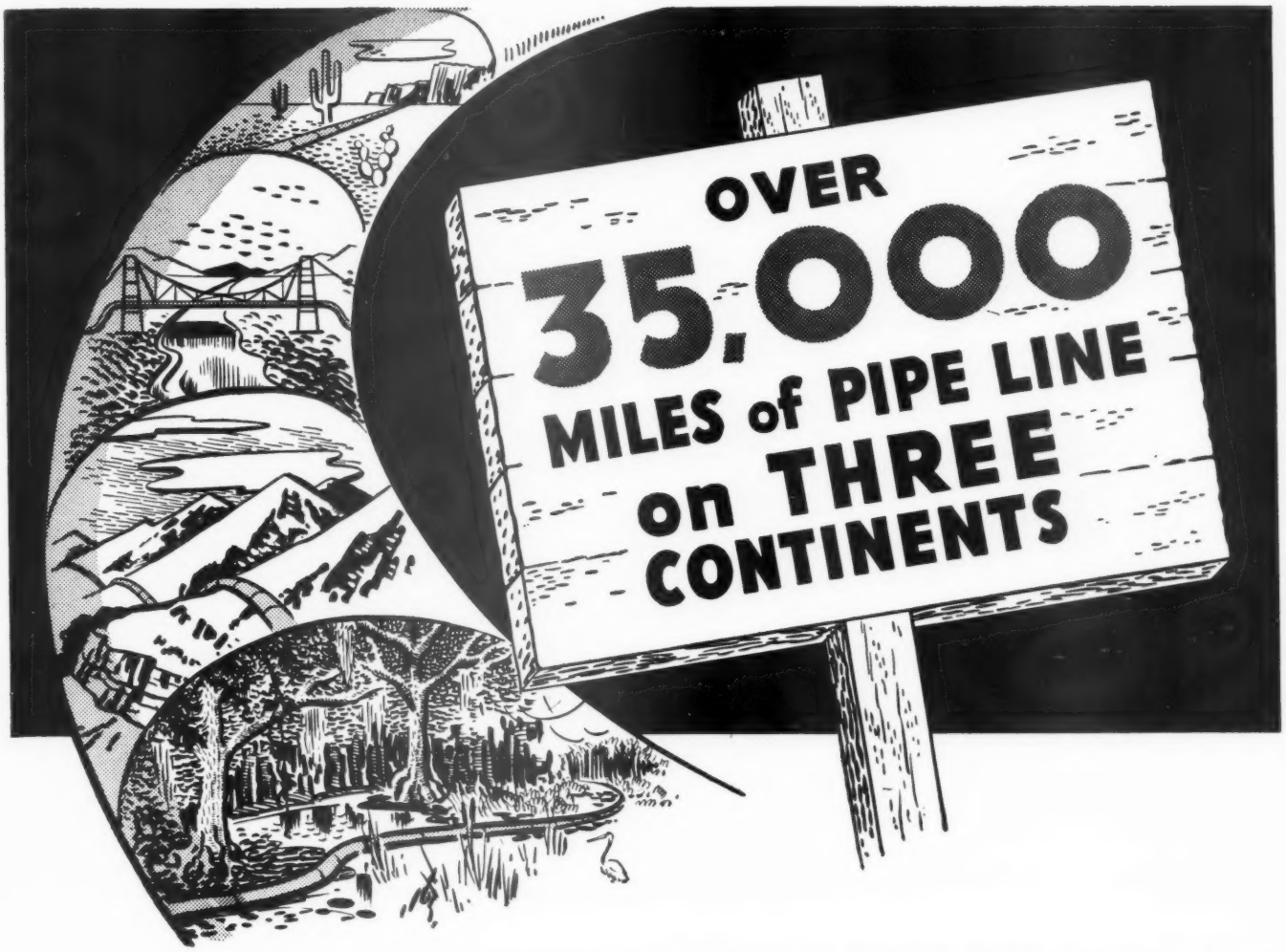
Heating and ventilating equipment. Heating and ventilating equipment consists of the following:

1. Pump room exhaust blowers: Above the windows between the pump room and meter slab are two explosion-proof exhaust blowers driven by three-phase explosion-proof motors, used for: (a) Maintaining a slight vacuum on the pump room to induce air leakage (if any) from the control room, and (b) provide sufficient air in the pump room to dissipate heat caused by the motors. Under normal conditions the pump room may be kept at the proper temperature in winter by use of only one blower and regulation of air entering the pump room, with heat being supplied by the operating motors. Air enters the pump room through filters just below the windows on the wall opposite the blowers.

Although the pump room blowers are on the selected explosion-proof circuit there is also provided the regular red indicating light and alarm function on the control desk to warn the operator during normal operation of failure of either blower. These lights and the alarm are on a separate circuit with other alarm functions and do not operate when the control desk is de-energized.

2. Control room and other non-hazardous rooms: A duct system with blower and heating units are used for maintaining a slight pressure and heating of the control room and other non-hazardous rooms. Intake for the system is from the hollow pylon at the front of the building with the make-up air coming from above and at a point distant from the hazardous area at the meter slab. A manually operated deflector governs the amount of recirculated air and make-up air going to the blower. The blower is driven by an explosion-proof, 220-volt, three-phase motor, and is able to maintain a slight pressure on the non-hazardous rooms. Thermostatically controlled electric heating units provide for automatic heating of these rooms.

A vane type air-actuated switch located in the main air duct is used to provide the regular alarm and control desk red indicating light functions for



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the no-flow condition. In addition to the red indicating light on the control desk circuit there is also provided on the explosion-proof circuit an explosion-proof red light mounted on the sequence control unit that is used as a warning of "no air flow" regardless of position of main outdoor breaker.

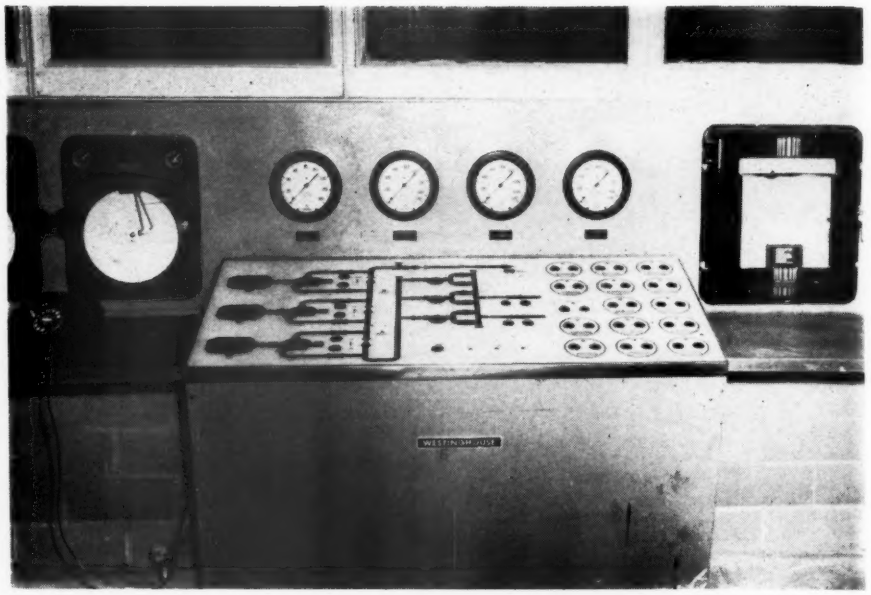
Control desk. The partition between the control room and pump room is for the most part wire glass with fixed steel sash. In this wall in the control room overlooking the pump room is the control desk. The wall between the two rooms is almost air tight. The control room floor is above the pump room floor enough to give the operator a clear view of the pump room. The control desk has both a vertical and horizontal section. The vertical section is low enough to permit a view of the pump room when standing at the control desk. The vertical section includes: (a) Suction pressure controller; (b) discharge pressure controller; (c) flow recorder (pneumatic receiver); (d) three recording pyrometers, and (e) four indicating pressure gauges.

The horizontal section of the control desk is laid out similar to piping as actually installed. Each tank and booster unit is represented by a circle enclosing start-stop buttons and the tank number for the booster concerned. An amber light within the circle is lighted to indicate when tank booster is in operation.

Motor-operated valves leaving the manifold on suction lines 1 and 2 are represented by the standard valve symbol. The closed position is represented by an illuminated amber letter "C" in the center of the valve body, and the open position is represented by an illuminated amber arrow pointing downstream.

The discharge valve on each meter is provided with limit switches in both the open and closed positions. These limit switches are used to show an amber lighted arrow through the meter unit when the valve is away from the closed position. An amber letter "C" is lighted when the valve is away from the full open position.

The main pump unit assembly consisting of pump and motor (represented by two appropriate symbols), suction and discharge motor-operated valves (represented by the standard valve symbols), and the bypass check valve (represented by the standard symbol), are aligned as three main pump units on the control desk and connected by proper and conventional pipe symbols. Amber arrows through the bypass piping pointing down-stream are illuminated when the unit with which the symbol is associated is not operating. Suction and discharge valves associated with non-operating pump units each have an illuminated amber letter "C" representing the closed position of the valves. When the main pump units are placed on the line, illuminated arrows on the bypass piping and closed position indicators on the suction and discharge valves are extinguished. Arrows showing flow through suction and discharge valves and through the pump are illuminated when the unit is on the line. When one or more units are on the line, an arrow showing fluid flow beyond Unit No. 3 is illuminated, and is extinguished when all pump units are down.



In the control room, overlooking the pump room, is the central control point for station operation where a lucite topped desk shows a schematic layout of the station.

On each pumping unit are red indicating lights to show when any of the various protective devices have functioned. These lights include:

(1) Pump bearings (2)..shutdown and alarm. Above 160 F.
(2) Pump glands (2)...shutdown and alarm. Above 150 F.
(3) Pump case.....shutdown and alarm. Above 125 F.
(4) Motor bearings (2).shutdown and alarm. Above 160 F.
(5) Motor windings (2).....alarm only. Above 240 F.
(6) Low suction press..shutdown and alarm. Below 25 psi.
(7) High case pressure*.....shutdown and alarm. Above 1200 psi.
(8) Motor overcurrent.....shutdown and alarm.
(9) Power failure.....alarm only, by air horn controlled through solenoid valve, on the explosion-proof circuit.

*For No. 2 and No. 3 units only.

It will be noted that only one light is used for two bearings or glands, etc. The recording temperature instrument can be used to determine which particular point of the two may have caused the device to function.

An explosion-proof push button station is provided and marked "Emergency Shut-Down", which operates main incoming power breaker cutting off all power to the station except that provided in explosion-proof circuits for station lights and blowers.

A push button station is provided that resets and silences the station alarm siren and extinguishes the flashing red lamp mounted on the pump room wall.

A red light in a circle on the outbound line on the control desk diagram shows when the device controlling line pressure has functioned.

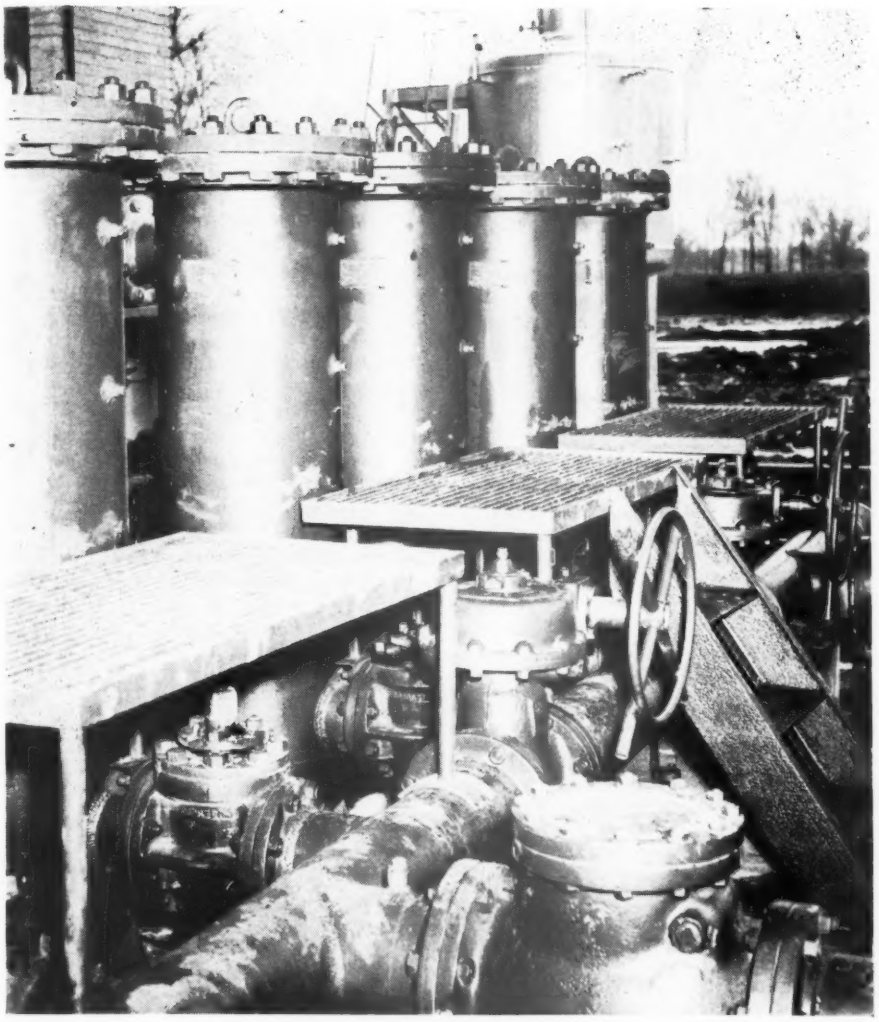
A sump liquid level switch sounds the station alarm and shows a red light on the control desk for the operation of the high level alarm.

An air pressure switch is set at approximately 30 psi and is used to protect against a low air supply to the pressure controllers and solenoid valves in the automatic vent system. The function of this switch does not include any tripping but only the sounding of the station alarm and the lighting of air indicating light on the control desk.

Tank farm and manifold. An individual tank farm booster pumping unit has been installed on each tank of the Humble Oil and Refining Company Sales Department. These units are of the vertical centrifugal type and are driven by 40-hp, 2300-volt, 60-cycle, 3-phase explosion-proof motors. Pumps are equipped with mechanical seals. Motor starters for these units are explosion-proof and weather-proof, and are mounted on concrete slabs adjacent to the pumping units. They are equipped with stop-reset push button stations for auxiliary control at pump unit location. Pressing the reset button restores the circuit for normal operation from the control desk, whereas pressing the stop button stops the units and prevents starting from the control desk. Start and stop push buttons and amber indicating lights for the operating condition of the unit are installed on the control desk in the pump station control room. Normal output pressure of this pumping unit is between 50 and 100 psi, depending upon the actual operating capacity and the gravity of the product being pumped.

Provision is made on the pump for a temperature protective switch as a protection against a continued non-flow condition. This device will stop and prevent operation of the unit when excessive temperatures exist, and is self-restoring but not self-starting.

A tank farm manifold is provided at this location that incorporates individual lines from each tank directly from the booster units, which are situated just outside the tank firewalls. Three headers are arranged to cross and are valved into each of the tank lines.



Vertical type strainers are used with felt sock inserts to protect the positive displacement meters from small particles of scale and debris.

One of these three crossing lines is used for filling of the tanks from one end by Humble Oil and Refining Company Sales Department. The other two lines are used for suction lines to the main line pumps. In other words, beginning at the tank line, two complete systems are provided to the meter slab at the pump station. On these two lines are motor-operated valves. A utility pump is installed at the manifold and tied into the three headers mentioned in a manner similar to the tank line connections. This utility pump can be used in an emergency for transferring product from one tank to another, or, in the case of breakdown of an individual tank booster unit, can be used to provide suction at limited flow from that tank to the main line station. This pumping unit is identical to the individual tank booster units including temperature protective equipment, but may be started and stopped by use of a "start-stop-reset" push button station located at the pump unit, as well as a start-stop button at the control desk. An amber indicating light on control desk indicates unit operation.

The two motor-operated valves on the suction lines to the main line units are 8 in. These two valves are equipped with hand wheels and can be operated manually if so desired. Individual push button stations are provided on the control desk for opening and closing each of these valves. Indicating lights on the control desk show the position of the valves, and are arranged so that both lights are on when the valve is in its intermediate position. These lights are amber and are provided with a mask to show an arrow at the open position and the letter "C" at the closed position. A pressure switch connected just upstream from each valve is used to prevent the opening of the valve in the event pressure is below 25 psi or predetermined minimum. Pressure switches are mounted on a small angle iron rack at the manifold. Valves are so arranged and electrically interlocked that both motor-operated valves cannot remain open at the same time. If both valves are closed then either may be opened manually or electrically. If one valve is open and an attempt is made either electrically or manually to open the closed valve, then the open valve closes electrically. Motors on these valves are 220/440-volt, 3-phase, 60-cycle, explosion-proof.

Meter slab equipment: Strainers and meters. Valve operation on the meter slab is determined by the particular operation desired. Small vertical type strainers, two for each meter, are used with felt sock inserts to protect the positive displacement meters from small particles of scale and debris. The two suction systems for the main line station will end at the up-stream header of the meters just ahead of the strainers. Header valves are provided to split the stream for the operation of individual meters. Valves on the meter slab and in connection with the meter units are provided with limit switches, which are used for the operation of indicating lights on the control desk. The control desk is designed such that piping shown is similar to that actually installed. Indicating lights for meter units, although actuated by valve position, show an amber lighted arrow for meter unit operation, and a small lighted "C" for the closed or non-operating condition of each meter unit. These same limit switches are used to provide proper arrangement of lighted arrows on meter discharge header.

Auxiliary equipment: Calibration system. The calibration system is an individual installation connected to the main line system only on the downstream side of each meter. In this way the calibrated liquid must be returned to the line at the point from which it was taken. One line directly from the meters to the calibration tank is used for both filling and emptying the tank. A 7½-hp, explosion-proof, 3600-rpm. 220/440-volt, 3-phase, 60-cycle, motor and turbine pump is used as a calibration pump unit. The pump has a capacity of 70 bbl per hr at 100 psi for gasoline. An open type starter for this motor is in the switchgear room, but an explosion-proof start-stop low-voltage protection push button station is adjacent to the pump near the building wall.

Drainage and sump system. A drainage system provides for the drainage of strainers, meters, pumps, and other points as required. In cases where drainage may contain water or foreign matter it is run through an oil-water separator before entering the sump tank. In some instances, such as in pump vents, the drainage goes directly to the sump tank. A sump pump installation, identical to the calibration pump installation, is used to pump the sump into the bypass line on the meter installation. This allows the sump to be pumped into the main line system either ahead of or behind the meters. The sump pump is self-priming and has a rating of 70 bbl per hr at 100 psi on gasoline. Operation of the liquid level switch on the sump tank has been described.

● **Hearne station.** Main line pumping units at Hearne station are of the same type and rating as at Baytown; however, there are only two units. Special equipment, such as pressure controllers and diaphram valve, line discharge pressure switch, sump tank level switch, station alarm system, emergency shutdown system, and heating and ventilating equipment, etc., also is the same as

at Baytown except for certain differences in the control desk. The vertical section of the desk contains only two units. The horizontal section is laid out similar to the piping as actually installed in this particular station. The manifold booster unit is represented on the control desk with a start-stop button and an amber light that is lighted to indicated operation.

Tank farm and manifold. A tank farm manifold is provided that incorporates individual lines from each tank. Two headers are arranged to cross and be valved into each of the tank lines. One of these two crossing lines is used for filling of the tanks from the main line. The other may be used for a suction line to the main line pumps. In other words, beginning at the tank lines, there are both a suction and a fill line to the meter slab at the pump station. A utility pump is installed at the manifold and tied into the two headers mentioned in a manner similar to the tank line connections. This utility pump can be used in an emergency for transferring products from one tank to the main line station. This pumping unit is identical to the individual tank booster units at Baytown but may be started and stopped by use of a "start-stop-reset" push button station located at the pump unit, as well as from the control desk. An amber indicating light on control desk indicates unit operation.

Meter slab equipment: Strainers and meters. Valve operation on the meter slab is determined by the particular operation desired. Small vertical type strainers, two for each meter, are used with felt sock inserts to protect the positive displacement meters from small particles of scale and debris. Two banks of meters are used, one for low pressure metering into or from tankage, the other for high pressure metering into the main line. Valves on the meter slab and in connection with the meter units are provided with limit switches, which are used for the operation of indicating lights on the control desk. The control desk is designed so that the piping shown is similar to that actually installed. Indicating lights for meter units, although actuated by valve position, show an amber lighted arrow for meter unit operation, and a small lighted "C" for the closed or non-operating condition of each meter unit. These same limit switches are used to provide proper arrangement of lighted arrows on meter discharge header.

Auxiliary equipment: Calibration system. A high pressure calibration pump installation is used to pump the calibration tank back into the line on either high or low pressure meters. This unit is a vertical triplex, 1½-in. by 2-in. stroke, with 15-hp, 220/440-volt, 3-phase, 60-cycle, explosion-proof, direct connected, gear head motor. This pump may also be used as a sump pump when high suction pressure at the station prevents use of the regular sump pump. This unit does not have automatic shut off on low sump tank level, however. The drainage and sump system are the same as at Baytown.

● **Sequence of operation, Baytown.** The sequence of operation at Baytown station is as follows:

I. *Starting of line from shutdown condition.* It is assumed that the line is shut down with a pressure pack of approximately 400 psi in order to detect line leaks during shutdown and also to prevent vapor spaces forming in the line. Baytown, when shut down, has the main incoming power breaker open, which leaves power available for exhaust and pressure fans, station and tank farm lighting. Station piping may or may not be drained according to the sequence of products to be pumped during the next cycle. All valves are closed, including tank gates, tank booster plug valves, manifold valves, all valves on the meter slab, and the outbound line plug valve at the scraper trap.

In preparation for operation, the operator first starts his pump room and control room blowers and checks the pump room, meter slab, and sump tank against any leakage that might have occurred during shutdown. Operator then proceeds to line up the pump station valves in the following order:

A. Open the gate valve on the tank that is to be used first in the pipe line cycle of operation.

B. Open the two plug valves at the tank booster pump for the tank to be used.

C. Line up manifold valves as desired from the proper tank up to the suction valve (motor-operated) for the suction system that is to be first in operation.

D. Arrange strainer and meter valves as desired for a clean strainer with the proper meter or meters as required.

E. Place meter ticket in meter printer.

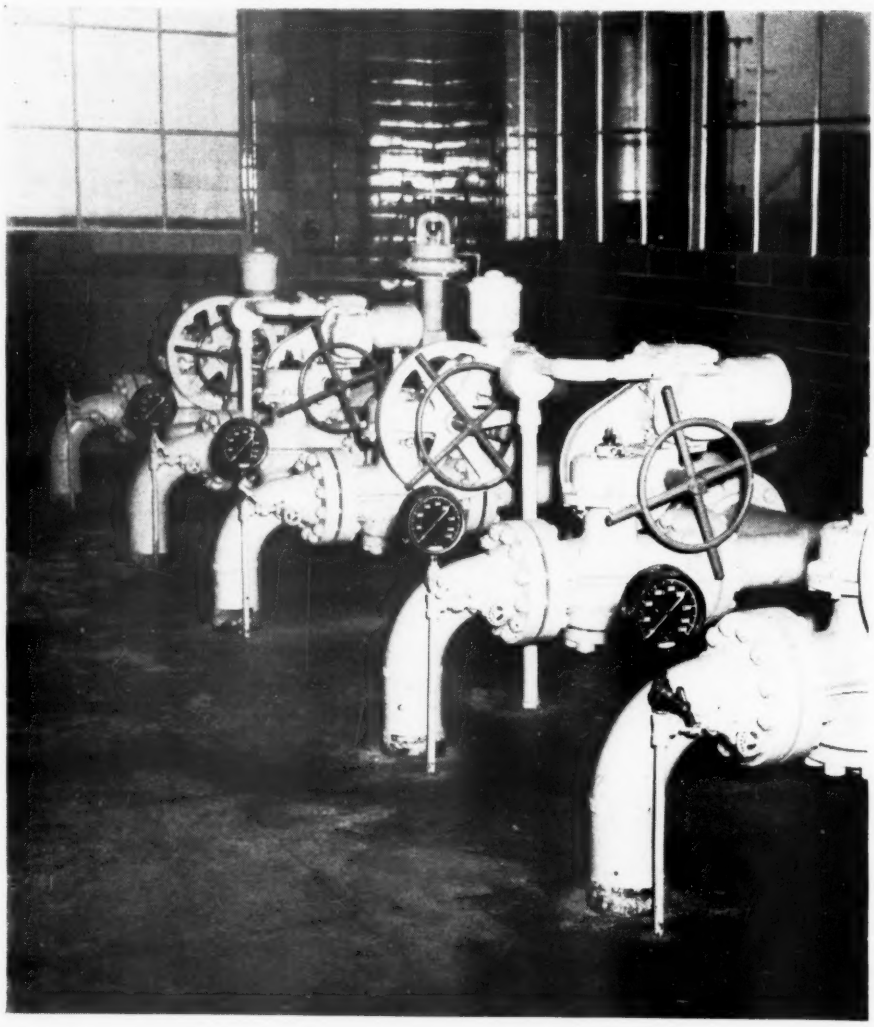
F. Open manually operated pump vent valve on all units to the proper position to allow desired venting flow.

G. Open plug valve at scraper trap to outbound line and any other valves in outbound line that are closed.

H. If the station piping had been drained when shut down, it may be necessary to open manually and close the motor-operated suction valve at the manifold to fill the station piping with liquid.

The line condition at this time is such that a direct system is available, filled with liquid up to the station check valve from the tank to the manifold through a meter or meters and through the station up to the suction and discharge valves of each main line pumping unit. The operator may now return to the control room for a final check with the

Motor-operated suction and discharge valves for individual pumping units.



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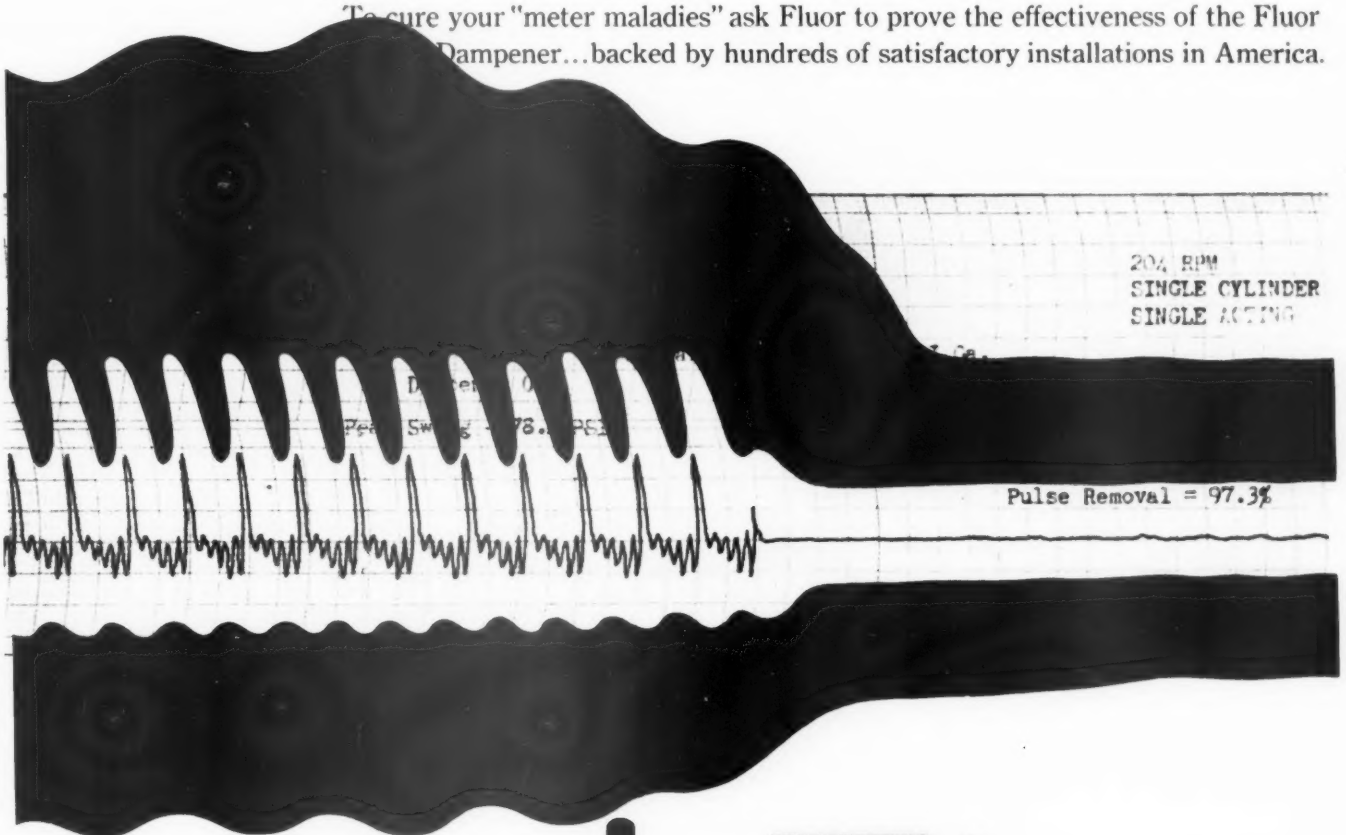

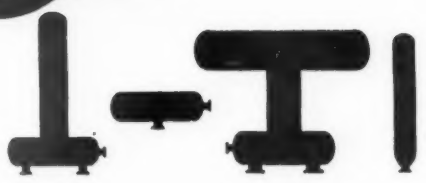

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dispatcher regarding the proper time and proper product for the initial pumping. The operator now checks the following points and sets pressure controllers as described:

I. Open manual valve at outlet of air storage tank.

J. Close main incoming power breaker at the incoming line panel.

K. Check incoming line voltage for a minimum of 2200 volts.

L. Set the suction pressure controller (on control desk) at 25 psi.

M. Set the discharge pressure controller at 50 psi above the line pack pressure but not above 1100 psi.

N. Check air pressure to controller and flow transmitter and set at 20 psi.

O. Manually start thermocouple pyrometer units for the main line pumps and motors that are to be operated. The toggle switch on the pyrometer case is to be used.

Up to this time no pumps have been operated and the only flow of liquid has been from tank head to fill the station piping system. The pump station is now ready for operation and can remain at this setup for as long as operator is at the station.

P. Operator presses start button on control desk for tank booster unit and observes amber light to show booster unit starter is in run position.

Q. Operator presses open button for motor-operated suction valve at manifold in suction system that has been lined up. If manifold valves have been arranged properly and a minimum pressure of 25 psi is available at the upstream side of the motor-operated valve, the valve opens. Lights on control desk show both the arrow and "C" when valve is in motion. The "C" is extinguished when the valve is in full open position.

R. The operator presses the start button on the main line unit that is to be used if pressure gauge on control desk indicates a suction pressure of 25 psi or more.

Various devices may function to interrupt or prevent the starting sequence of the main line units. These have been described.

If the suction pressure at the suction flange of the pump being started is not above 25 psi, the main line motor will not start and the motor-operated suction valve for this unit will automatically return to closed position at the termination of the normal sequence time. The suction valve for the unit will not open, initiating the starting sequence unless the reset push button in the pump room at the unit has been pressed subsequent to use of the stop push button. The temperature protective pyrometer units should not cause difficulty in the starting of the main line units, for critical temperatures will not be present at this time. The pyrometer for a main line unit must be operating before starting is attempted. Temperature protective devices after a period of operation may indicate critical temperatures that will shut the unit down and sound the station alarm. Excessive motor winding temperature will not shut the unit down but will show its indicating light and sound the station alarm. The unit when shut down by any protective device will cause the unit suction and discharge valves to return to their closed positions if power is available.

During starting, the automatic venting system causes the vent line to be opened at all times that the discharge valve is away from its fully opened position.

Arrangements for simultaneous opening of takeoff valves at a terminal and the starting of Baytown station should be made by the dispatcher. The main line unit should never be in operation for more than a short time (probably two minutes) at the no-flow condition. If one unit is not producing enough pressure to open the station check valve, this unit would then operate at the no-flow condition. The flow meter on the control desk shows the line flow in the station outbound line. When the unit or units are in operation, the discharge pressure controller setting may be gradually increased to the desired outbound line pressure or to a maximum of 1100 psi. The purpose in using the discharge pressure controller to gradually apply the output pressure of the pumps to the main line is to prevent the building up of pressure surges and to obtain a smoother pressure increase in the main line.

II. *Starting a unit with one unit in normal operation.* In starting a second unit, the operator should determine the

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line pressure expected when two units are in use. The operator should observe the following sequence in adding the second unit at this location:

A. Set the discharge pressure controller at a pressure slightly above the output pressure of the unit operating.

B. Start the thermocouple pyrometer unit for the pump that is to be started.

C. Press the start button for the unit to be started.

D. Gradually increase the discharge pressure controller to the desired outbound line pressure or a maximum of 1100 psi.

As the discharge valve on the unit being started begins to open, the check valve, which is between the suction and discharge valves, will close gradually and the flow will then be through this pumping unit.

If, during the starting sequence, the main line motor fails to start, the motor-operated suction valve returns to its closed position.

III. *Switching tanks while line is in normal operation.* The station operator at any time up to several hours prior to the expected changing of products in the line may make all changes that must be made manually to provide for this operation. The operator should have information from the dispatchers regarding the proper time and product change that is to be made. The operator may first open the tank gate (if closed) to the new tank that is to be used and also open both plug valves at the tank booster unit. He next lines up the tank farm manifold from the new tank into the suction system that is not in use at that time. The meters and strainers to be used for metering the succeeding product may be properly arranged and the system filled up to the meter discharge valve, which is manually opened just before the switch is made. At the time that the change is to be made the operator should be in the control room and available for final instructions from the dispatcher. The booster unit for the succeeding product tank is first started, and the proper operation of this unit is indicated on the control desk by the amber light for this unit. The operator then presses the open button on the motor-operated suction valve, and the two motor-operated valves at the manifold open and close simultaneously to switch from one suction system to the other. The operator should then close the manual valves used in the suction system and at the manifold for the product formerly pumped.

IV. *Normal shutdown of units.* When it is desired to shut down a main line pumping unit, the operator should gradually reduce the outbound pressure by using the discharge pressure controller at the control desk. When at least 75 per cent of the output pressure of one unit is being throttled at the control valve, the operator may then press the stop button for the pumping unit desired to be shut down. When the stop button is pressed, the suction and discharge valves return to the closed position, the main line motor stops, and the pump is vented automatically.

V. *Emergency shutdown.* An emergency shutdown push button is provided on the control desk that operates the main incoming power breaker and leaves only the blower units and station and tank farm lights in operating condition. This emergency push button is intended primarily for use at any time that explosive vapors may be present in the control room or other rooms in the non-hazardous area, but may be used in any emergency. Depending upon the conditions that constitute the emergency, the operator may use the outside explosion-proof telephone for reporting to the dispatcher or receiving instructions for station repairs. After the emergency shutdown procedure has been used, the operator should, when it is safe, manually close all motor-operated valves and return the station to the normal shutdown conditions.

VI. *Procedure in event of failure of electrical equipment.*

1. Complete station shutdown: An involuntary station shutdown, including lighting, due to power failure will be accompanied by a 30-sec blast of the power failure alarm (air whistle) mounted on the station roof. Station operator should notify the dispatcher and wait three minutes for restoration of power, which will be indicated by operation of electric clock. If power is not restored at end of three minutes, operator will proceed as follows:

a. Manually close all open or partially open suction and discharge mo-

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tor operated valves associated with main line units.

b. Manually close all open or partially open suction system motor operated valves. Should electric power be restored prior to or during the manual operation of closing the motor operated valves, the station operator may electrically close all open motor operated valves by:

(1) Closing the main incoming (outdoor) power breaker at the switchgear (incoming line panel), which will automatically close all open or partially open suction and discharge motor operated valves associated with the main line units.

(2) Closing all open or partially open suction system motor operated valves by pressing the proper close button on control desk.

c. Resume pumping in accordance with the dispatcher's instructions and the prescribed procedure for starting line from shutdown condition after power is restored.

2. Main line unit shutdown:

a. In case of automatic shutdown of one or more main line units due to high outbound line pressure the dispatcher should be notified and the condition should be corrected, if possible, by use of pressure controller.

b. In case of automatic shutdown of any main line unit due to excessive case, gland, or bearing temperatures, the idle unit should be placed in service and the dispatcher notified.

3. Excessive main line unit winding temperature:

a. Excessive winding temperatures may be caused by overload of motor with resultant high amperage on motor. Motor load may be reduced by lowering outbound line pressure. If, after 15 min operation at 90 amp or less to main line unit motor, overheating continues, the unit should be shut down or replaced and dispatcher notified.

4. Tank farm boosters: Should tank farm boosters fail to start after involuntary shutdown, wait three minutes to allow overload relays to restore, then:

a. Start unit from push button on control desk.

b. Notify dispatcher and C. & E. foreman in event unit fails to start or shuts down again automatically.

5. Auxiliary electrical equipment failure: Should the air compressor, sump pump, calibration pump, heating units, pump room exhaust fans, or control room pressure fan fail to operate, the station operator should:

a. Reset overload relays on motor starter or contactor and place unit in service.

b. Report trouble to the Division C. & E. foreman in event this does not correct the trouble.

6. Tank farm lights: Tank farm lights are controlled by an electrically driven time switch (clock) placed in the rear of the auxiliary power panel, and it will be necessary to reset the time switch (clock) after each opening and closing of the main outdoor power breaker. Seasonal changes will require adjustment of "On" and "Off" dogs on time switch to insure operation of lights during hours of darkness.

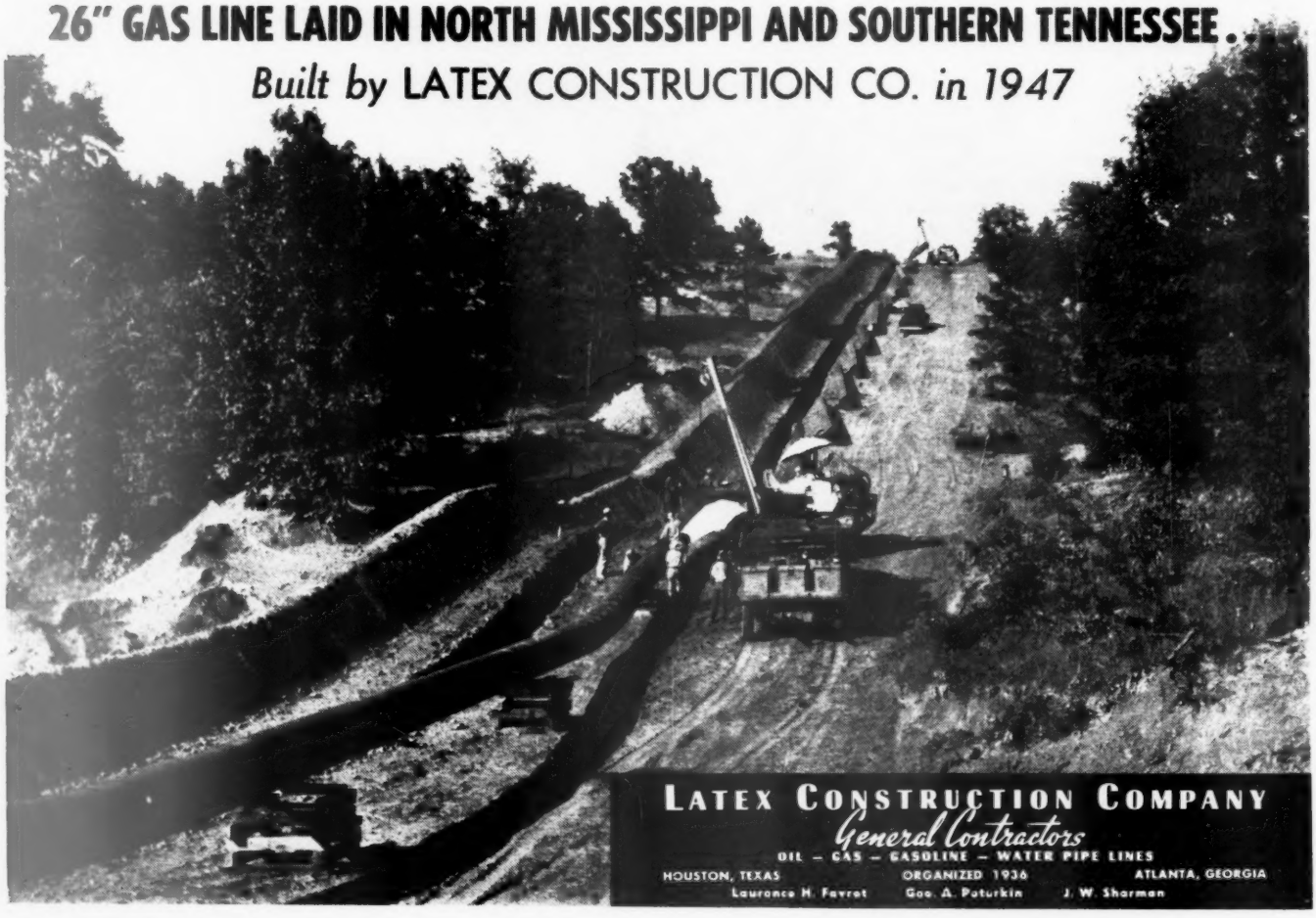
● **Sequence of operation, Hearne.** The sequence of operation at Hearne station is as follows:

1. *Starting of line from shutdown condition:* It is assumed that the line is shut down with a pressure pack of approximately 400 psi in order to detect line leaks during shutdown and also to prevent vapor spaces forming in the line. Hearne, when shut down, has the main incoming power breaker open, which leaves power available for exhaust and pressure fans and station lighting. Station piping may or may not be drained according to the sequence of products to be pumped during the next cycle. All valves should be closed, including tank gates, manifold valves, all valves on the meter slab, and the outbound and inbound line plug valves at the scraper traps.

In preparation for operation, the operator first starts his pump room and control room blowers and checks the pump room, meter slab, and sump tank against any leakage that might have occurred during shutdown. Operator then proceeds to line up the pump station valves in the following order:

A. Line up manifold valves as desired.

B. Arrange strainer and meter valves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as desired for a clean strainer with the proper meter or meters as required.

C. Place meter ticket in meter printer.

D. Open manually operated pump vent valve on all units to the proper position to give the desired venting flow.

E. Open plug valve at scraper trap to outbound line and any other valves in outbound lines that are closed. This operation and the arrangement of other valves depend upon the results desired.

F. If the station piping had been drained when shut down, it may be necessary to manually operate valves to fill the station piping with liquid.

The operator may now return to the control room for a final check with the dispatcher regarding the proper time and proper product for the initial pumping.

Operator now checks the following points and sets pressure controllers as described:

G. Open manual valve at outlet of air storage tank.

H. Close main incoming power breaker at the incoming line panel.

I. Check incoming line voltage for a minimum of 2200 volts.

J. Set the suction pressure controller (on control desk) at 25 psi.

K. Set the discharge pressure controller at 50 psi above the line pack pressure but not above 1100 psi.

L. Check air pressure to controller and flow transmitter and set at 20 psi.

M. Manually start thermocouple pyrometer units for the main line pumps and motors that are to be operated. Toggle switch on pyrometer case is to be used.

The pump station is now ready for operation and can remain at this setup for as long as operator is at the station.

N. Operator presses start button on main line unit that is to be used if pressure gauge on control desk indicates a suction pressure of 25 psi or more.

Various devices may function to interrupt or prevent the starting sequence of the main line units. This equipment has been described.

If the suction pressure at the suction flange of the pump being started is not above 25 psi, the main line motor will not start and the motor-operated suction valve for this unit will automatically return to the closed position at the termination of the normal sequence time. The suction valve for the unit will not open, initiating the starting sequence, unless the reset push button, which is in the pump room at the unit, has been pressed subsequent to use of the stop push button. The temperature protective pyrometer units should not cause difficulty in the starting of the main line units, for critical temperatures are not to be present at this time. The pyrometer for a main line unit must be operating before starting is attempted. Temperature protective devices after a period of operation may indicate critical temperatures that will shut the unit down and sound the station alarm. Excessive motor winding temperature will not shut the unit down but will show its indicating light and sound the station alarm. The unit when shut down by any protective device will cause the pump unit suction and discharge valves to return to their closed positions.

During starting, the automatic venting system causes the vent line to be opened at all times that the discharge valve is away from its fully opened position.

Arrangements for simultaneous opening of take-off valves at a terminal and the starting of Hearne station should be made by dispatcher. The main line unit should never be in operation for more than a short time (probably two minutes) at the no-flow condition. If one unit in operation is not producing enough pressure to open the station check valve, this unit would then operate at the no-flow condition. The flow meter on the control desk shows the line flow in the station outbound line. When the unit or units are in operation, the discharge pressure controller setting may be gradually increased to the desired outbound line pressure or to a maximum of 1100 psi. The purpose in using the discharge pressure controller to apply gradually the output pressure of the pumps to the main line is to prevent the building up of pressure surges and to obtain a smoother pressure increase in the main line.

Procedure for starting a unit with one unit in normal operation is the same as at Baytown station. To make a normal or emergency shutdown of units the procedure followed also is the same as at Baytown. ★★★

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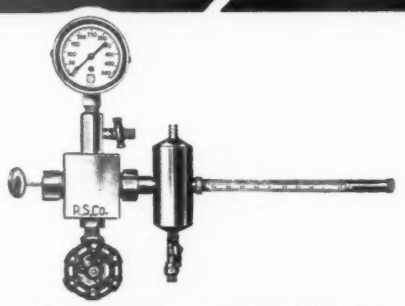

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By D. K. STEPHENS, Superintendent, Transmission Pipe Lines,
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FIFTEEN to twenty years ago when long distance transmission of natural gas by means of large diameter pipe lines was more or less in its infancy, the capacity of such lines was greater than the demand for the product that they transported. Consequently, interruption in the flow of gas occasioned by necessary repairs, construction purposes, or for any other reason seldom caused inconvenience to consumers or loss of sales. During that period, it was a common practice to "shut-out" an eight or ten mile section of pipe line when it was necessary to change a broken valve, to replace some defective pipe, or to install new fittings.

It was not long until the demand for natural gas began to tax the capacity of the original long distance, large diameter pipe lines, and even though the former capacity of many of the pipe line systems has been doubled and in instances tripled, presently it is impossible to keep abreast of the demand for natural gas. Therefore, it became essential that shut-outs be avoided in order to conserve gas, to maintain sales, and to minimize interruptions to consumers. The greatest factor devised in reducing shut-outs to a minimum on natural gas pipe lines has been the development of the electric arc method of welding against pressure. This article will enumerate some of the methods of welding against pressure that have been developed during the past decade and that are in use on the Panhandle Eastern Pipe Line Company system. Welding against pressure is done only by welders who have had the benefit of training received from some of the older and more experienced welders who helped to devise many of the welding methods used by Panhandle Eastern.

● **Maintenance.** Figs. 1 and 2 show the method of installing a split welding sleeve over a coupling, a long sleeve, or a circumferential weld. A shoe with curved base to fit the sleeve is placed on the top half of the sleeve, then a hydraulic jack, having a yoke slipped over or welded to the top of the plunger, is set in this base. Next, the bottom half of the sleeve is placed in line under the top half, and then a chain is placed around the sleeve, over the yoke on the jack, and hooked snugly. A few pumps of the jack will snap both halves of the sleeve into place. Before welding is begun, a heavy safety clamp is bolted on the line at each end of the sleeve as close to the sleeve as possible without interferring with the welding operation.

The safety clamps shown in Fig. 1 are used in all the methods shown in other figures where the welding is done directly on a large diameter pipe line that is under pressure. The longitudinal welds are made first, then the end welds.

Welding sleeves can be used to repair leaks in couplings, long sleeves, and pipe as well as to reinforce pipe at couplings or welds. If welding sleeves are used to repair a leak, a gasket is placed around the leak and the gas is vented by welding a collar of the proper size on the top half of the sleeve and a vent pipe is extended from the collar to a point above the ditch. (See Fig. 4-A). The vented gas should be ignited at the top of the pipe vent before welding is begun. After the sleeve is welded, the vent is removed, a bullplug is screwed into the vent collar and welded.

Sometimes the replacement of one or more joints of badly corroded pipe can be avoided by following the method illustrated in Fig. 3. This method or procedure consists of splitting pipe of the same size as, or larger than, the corroded sections and welding the split pipe over the corroded sections of line. If the halves are cut from the same size pipe, each half should be cut from separate pieces of pipe, for they must be a little larger than half the diameter and spread in order to fit the outside diameter of the pipe that is to be covered. If such halves are cut from larger diameter pipe, the ends are swaged to the OD of the pipe that is to be covered. All longitudinal welds should be made first. Practically the same procedure is followed when half-soling a joint of pipe.

Occasions arise when not only is it more convenient and economical, but it is necessary to use an emergency sleeve or a saddle in repairing a leak in the walls of a joint of pipe; however, such repairs are temporary only, and permanent repairs by one of the several methods shown in Fig. 4 are made as soon thereafter as is practicable. When the leak is very small, a small flat rubber gasket is used under the patch as shown at "A" on Fig. 4. The method of clamping the patch in place (hydraulic jack and chain described in Fig. 1) generally is sufficient to stop the leak and no vent is needed.

Fig. 4—"B" shows a method of using a patch to cover several leaks, a badly pitted area, or both. The leaks are surrounded by a heavy rope-like gasket similar to a coupling rubber, a vent of sufficient size is welded on the plate within the area enclosed by the gasket, and the edges of the plat are cupped or turned down slightly so that as the patch is clamped in place the edges will be close enough all around for welding. A vent pipe should be used to carry the gas

FIG. 1. "Pumpkin" over coupling or long sleeve.

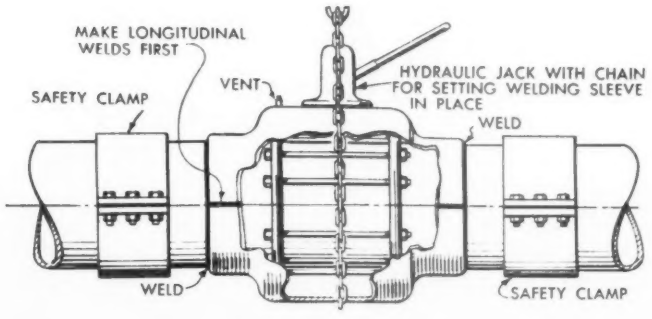
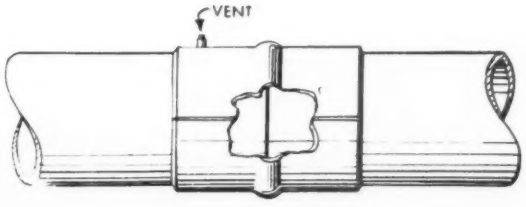


FIG. 2. Split welding sleeve over circumferential weld. (Same installation method as shown in Fig. 1).



out of the bell-hole and the vented gas should be ignited before welding is begun.

Fig. 4—"C" illustrates the method of placing a small patch over a single leak in which a rubber cone gasket is used and can be made and installed in the same manner as the patch at Fig. 4—"B."

Sometimes, it is not convenient at the time to move a welding machine to the location where a permanent repair must be made. In such instances a welding saddle, such as is shown at Fig. 4—"D," is economical to use. In the installation of this saddle, the plate is flanged to take the U-bolts and is perforated above the flange. At a future date the upper edges of the perforations are welded to the pipe, the bolts are removed, and the flanges are cut off along the line of the upper edges of the perforations. The remaining steel plate is then welded all the way around.

Fig. 5 illustrates a method of repairing a leaking weld at a side gate. This repair is made by splitting a bullplug or swage nipple and fitting the two halves around the tap nipple and against the main line pipe. The longitudinal welds are made first and then the ends are welded to the main line and tap nipple, respectively. The vent is then closed in the usual manner. The possibility of repairing such a leak by this method depends on the length of the nipple between the weld and the side gate. If the nipple is too short, enough room is not available for making the weld and the repair will have to be made as shown in Fig. 8, which will be described later, and a new side gate installed.

● **Construction.** The demand for more gas and the storage of steel pipe both during and since the last war has made it necessary for the natural gas pipe line companies to obtain additional capacity by increasing operating pressures. Increased pressures often require a substitution of some of the valves originally installed on the line with valves of higher GWP. Such was the case with Panhandle Eastern Pipe Line Company. A number of small valves from 2 in. to 6 in. had to be replaced. Because the valves were scattered along a thousand or more miles of main line and were on approximately 70 different sections (a section is that part of the line between main line gate valves eight to ten miles apart), a shut-out and a blowdown of each section to replace a gate would be exceedingly expensive, cause a great deal of inconvenience to customers by curtailing the supply of gas, and would waste enormous quantities of gas. All this was avoided by using the methods shown in Figs. 6, 7, and 8. In Fig. 6 the lateral line was shut out between the tap gate and regulator or measuring station, generally a matter of only a hundred feet or so. The lateral line was cut and the proper GWP valve was welded in the line a few feet downstream from the old tap gate. As the lateral line was packed or switched to another line before shut-out, there was no interruption in service during the period that the line was cut and the new valve was welded in the line.

After the installation of the new valve, the old tap valve was "bottled" while *open*. The "tank" used to bottle the valve was prefabricated as far as possible in the shop. This tank consists of two welding heads of the size required (for a 2-in. valve we used 16-in. welding heads) and a piece of pipe of the same diameter and of sufficient length so that the tank will be large enough to encase the valve. The only welding required in the field was that of welding the bottom welding head to the top part of the tank, welding the tank to the lateral line on each side of the tap gate, and welding any required bracing.

Before the tank was placed over the gate, the stuffingbox on the gate was loosened to permit a slight leakage of gas. This leakage was disposed of during the welding by a vent in the top of the tank. After the welding was completed, the vent was closed in the usual manner. The leaking stuffingbox soon equalized the pressure within the tank with that of the main line, thus there was no chance that the higher operating pressure would rupture the valve within the "tank" or "bottle."

In some instances, it was found that the nipple between the tap gate and the main line was too short to bottle the gate as shown in Fig. 6, as there was not room to do the necessary welding between the gate flange and the main line. In that case, a method similar to that shown in Fig. 8 was used, the only difference being that the lateral line ex-

FIG. 3. Pipe of various lengths, split and welded over weak sections of line.

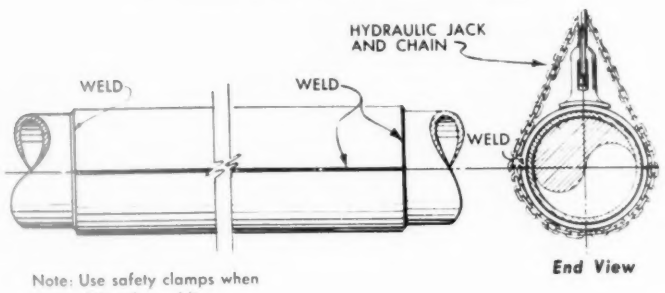


FIG. 4. Welded patches.

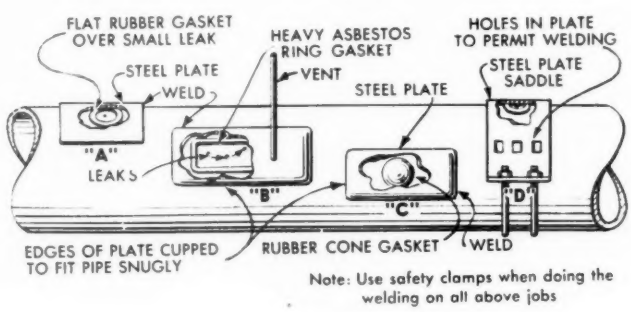


FIG. 5. Repair to leaking side tap.

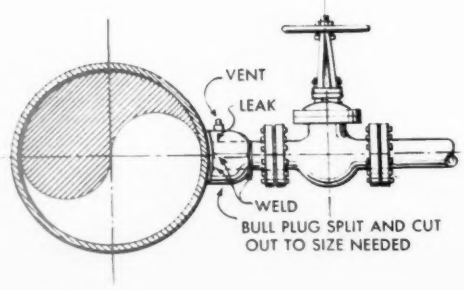
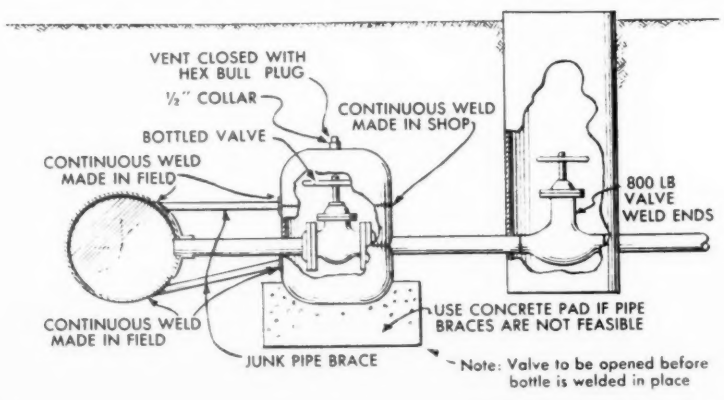


FIG. 6. Typical arrangement for bottling side tap gate valve.


VENT CLOSED WITH HEX BULL PLUG
½" COLLAR
CONTINUOUS WELD MADE IN SHOP
BOTTLED VALVE
CONTINUOUS WELD MADE IN FIELD
800 LB VALVE WELD ENDS
USE CONCRETE PAD IF PIPE BRACES ARE NOT FEASIBLE
CONTINUOUS WELD MADE IN FIELD
JUNK PIPE BRACE
Note: Valve to be opened before bottle is welded in place

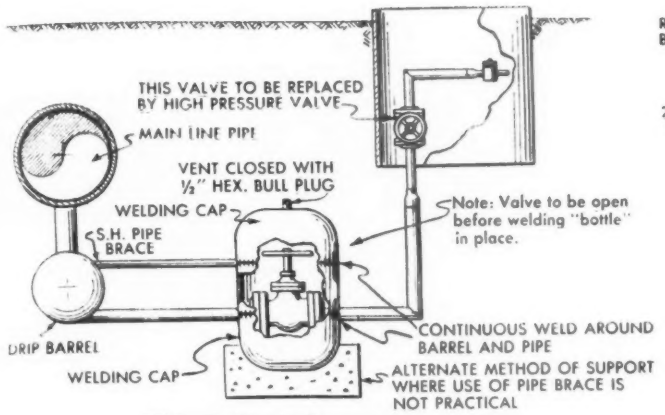

THIS VALVE TO BE REPLACED BY HIGH PRESSURE VALVE
MAIN LINE PIPE
VENT CLOSED WITH ½" HEX. BULL PLUG
WELDING CAP
S.H. PIPE BRACE
Note: Valve to be open before welding "bottle" in place.
DRIP BARREL
CONTINUOUS WELD AROUND BARREL AND PIPE
WELDING CAP
ALTERNATE METHOD OF SUPPORT WHERE USE OF PIPE BRACE IS NOT PRACTICAL

FIG. 7. Typical arrangement for bottling drip blow-off gate valve.

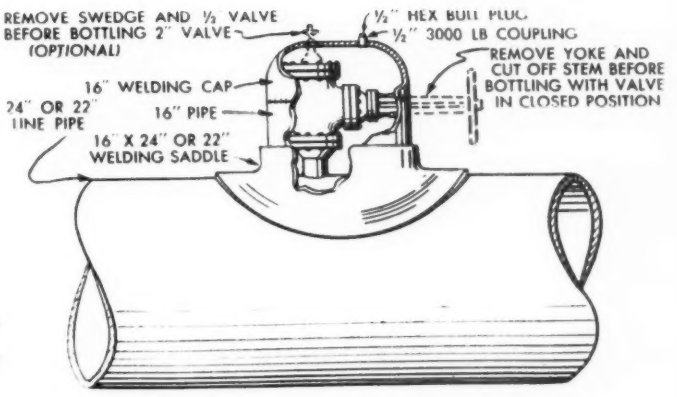

REMOVE SWEDGE AND ½ VALVE BEFORE BOTTLING 2" VALVE (OPTIONAL)
½" HEX BULL PLUG
½" 3000 LB COUPLING
REMOVE YOKE AND CUT OFF STEM BEFORE BOTTLING WITH VALVE IN CLOSED POSITION
16" WELDING CAP
24" OR 22" LINE PIPE
16" PIPE
16" X 24" OR 22" WELDING SADDLE

FIG. 8. Typical arrangement for bottling pitot tube settings.

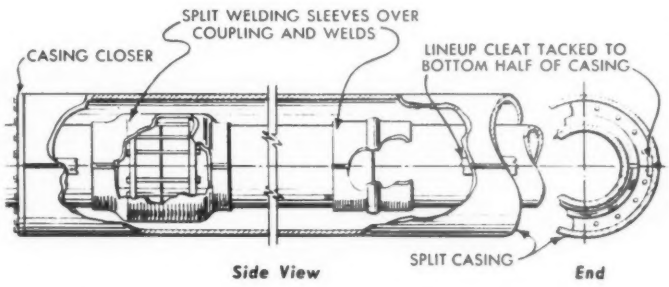


FIG. 9. Installing casing over line in service at new highway or new railroad crossing.

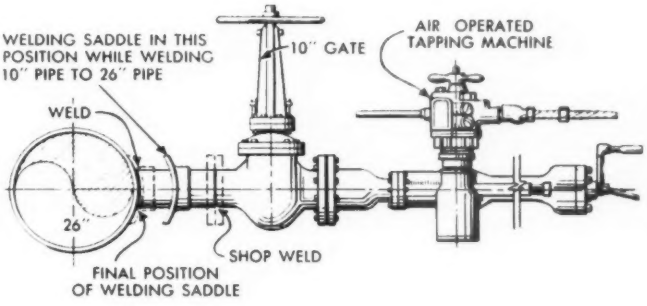


FIG. 10. Installing side gate.

tended out through the top of the welding head and was welded to the head. Also, if it was necessary to cut off the yoke or stem to reduce the size of the tank, the valve was opened first and the stem pinned in that position before cutting it off. This was done to prevent the valve disk from dropping to a closed position at any future date and thereby shutting off the lateral line.

Fig. 7 illustrates the method of bottling a valve on a drip. Approximately the same procedure is used as in bottling the side tap gate.

Fig. 8 shows how any side tap valve, no longer needed, was made safe for higher working pressures. These valves were bottled in a closed position, but the stuffingbox was loosened to permit equalizing of pressure within the bottle as in the other two cases.

Quite frequently, on account of improvements made in second class roads or because of the construction of new highways or railroad crossings, it becomes necessary to encase a line that is in service. Fig. 9 shows a method Panhandle Eastern Pipe Line Company has used a number of times in performing this type of job without the necessity of a shut-out. All couplings, sleeves, and circumferential welds that will be in the cased part of the line are covered with split welding sleeves. Pipe casing of a diameter that will go over the largest diameter sleeve is then split and a cleat approximately ¼ in. by 2 in. is tack-welded to each inside edge of the bottom half of the casing. The cleats extend to within 4 or 5 in. of the casing end. The two halves are centered over the pipe and welded, after which standard type of end closers are used to seal the ends and a vent pipe is extended to the fence line in the usual manner.

The installation of side gates on lines in operation without a shut-out or reduction in pressure is common practice. Panhandle Eastern has made such taps of all sizes up to 12 in. Fig. 10 shows the installation of a 10-in. valve designed with one welding end and one flanged end. The nipple is welded on to the gate in the shop. A welding saddle is slipped over the nipple before the nipple and gate is blocked in place. The nipple is welded to the line, then the welding saddle is moved into place and is welded to the line and the nipple. The next step is to bolt in air-operated tapping machine to the gate flange, the gate is opened, and the tap is made. About 6 or 8 minutes are required to make the tap. The bit is then withdrawn far enough to clear the gate valve disk, gate is closed, and pressure released between the gate disk and tapping machine head before unflanging the tapping machine.

The power-driven machine is used on taps from 2 in. to 12 in. A hand-operated machine is used for taps smaller than 2 in. ★ ★ ★

Production heavy in five states

The bulk of the world's oil produced to date has been supplied by five states: Texas, California, Oklahoma, Louisiana and Kansas. These states are shown to have produced 51.8 per cent of all the oil produced by the entire world since the first commercial well was drilled in Rumania in 1857. Texas has produced to date nearly as much oil as all of Europe, Russia, the Middle East and the Far East. California has produced as much as all of the Western Hemisphere outside of the United States. Oklahoma has produced as much as Russia, and Louisiana's oil production has equaled cumulative production of the entire Far East.—*The Petroleum Data Book*.

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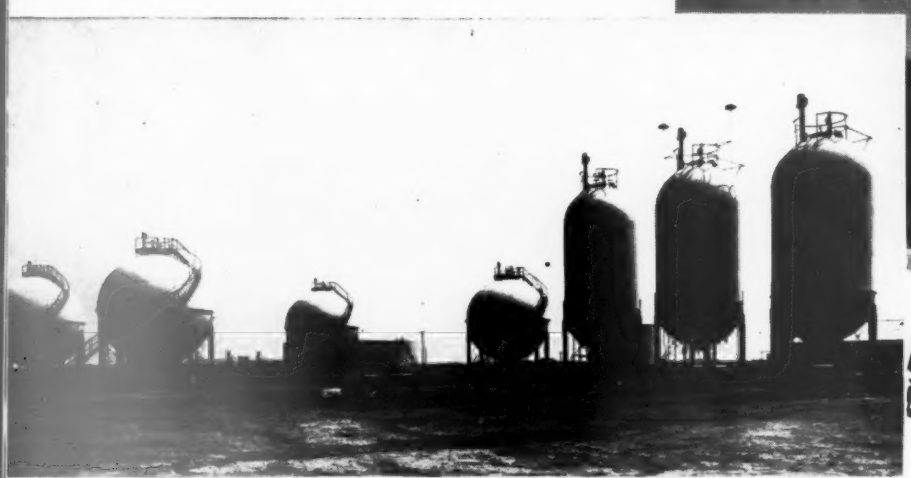

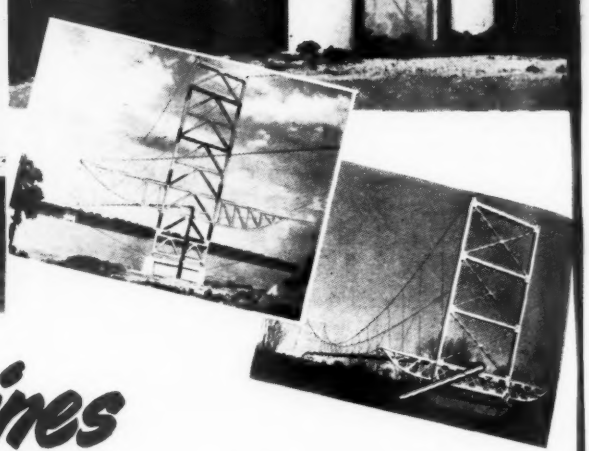

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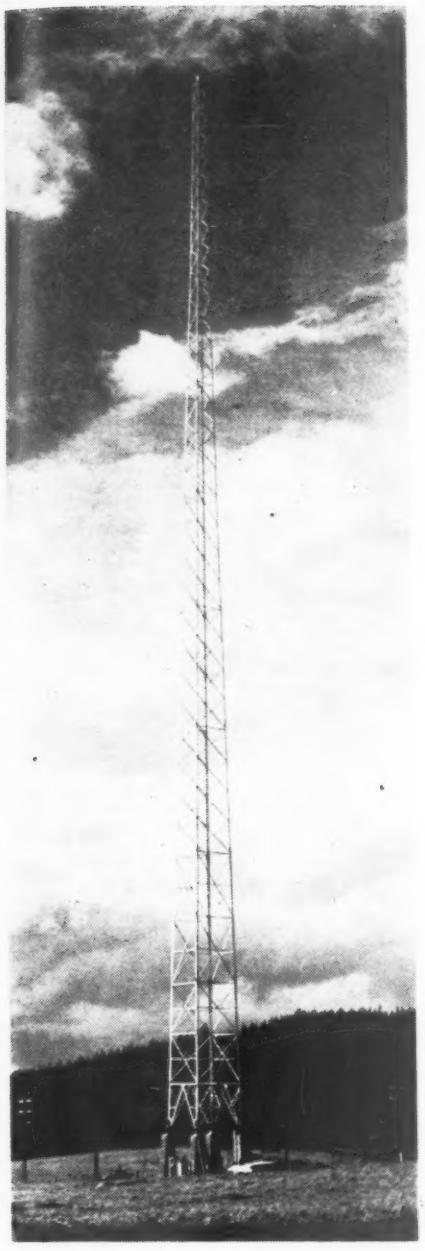
MOBILE RADIO

By WARREN T. BULLA, Superintendent, Communications and Dispatching, Natural Gas Pipeline Company of America



Typical radio tower for fixed station that works with mobile units. Heights may vary from 100 to 300 ft. The antenna, like those required for most FM installations, is only a few feet in length and is installed on top of the tower.

DEPENDABLE service is probably the slogan of every pipe line company operating in these United States, whether the commodity be oil, gas, or petroleum products. In fact, the American way of life is so dependent on those products in this modern fast-moving age that every effort must be directed toward a continuous flow of the products handled.

EXCLUSIVE

The commodities handled through such pipe lines are essential in the lives of more than one-half of the United States population. Interruption in much of this service constitutes a danger to life and property. In industry there are millions of applications of gas and oil in industrial processes.

The danger from an interruption in service to these installations is the loss of work in progress, worth hundreds of thousands of dollars, and the complete shutdown of a plant with the resultant loss of pay to employes.

In event of war, the national effort would be seriously hampered if there were any major interruption in service at any time.

Oil and gas companies have taken and are taking advantage of every facility to make their operation safer and more dependable.

Communication is vital to proper operations. All existing forms of communication are presently being used.

Two-way mobile radio is the fastest, most dependable, and best adapted means of communication to insure prevention of emergencies, to effect speedy repairs, to safeguard the public, and to conduct pipe line operations.

An important forward step in dependable assurance has been made by a number of pipe line companies. Two-way radio service, which augments their existing communication systems of telephone and telegraph, has been installed to provide essential contacts between important control points and field operators, so essential in maintaining an uninterrupted service.

Radio offers the only practical means of maintaining communications with field forces on wheels or aboard ship.

In view of the fact that so many gas utility and petroleum operators will be interested in radio in the near future, I believe certain reference data will be helpful.

The radio spectrum is commonly considered to have a lower limit of 30,000 cycles (30 kilocycles) and an upper limit at the present state of development of 30,000,000,000 cycles (30,000 megacycles).

Band	Designation	Frequency (kc)	Spectrum space (kc)
Low	LF	30-300	270
Medium	MF	300-3,000	2,700
High	HF	3,000-30,000	27,000
Very high	VHF	30,000-300,000	270,000
Ultra high	UHF	300,000-3,000,000	2,700,000
Super high	SHF	3,000,000-30,000,000	27,000,000

Note that the spectrum space, which is a rough measure of the number of stations that can be accommodated, occupied by each band is ten times that of the next lower band.

In dealing with frequency allocation problems, two major factors must be considered:

(a) The type of intelligence to be transmitted.

(b) How the transmitted wave acts along its path of travel.

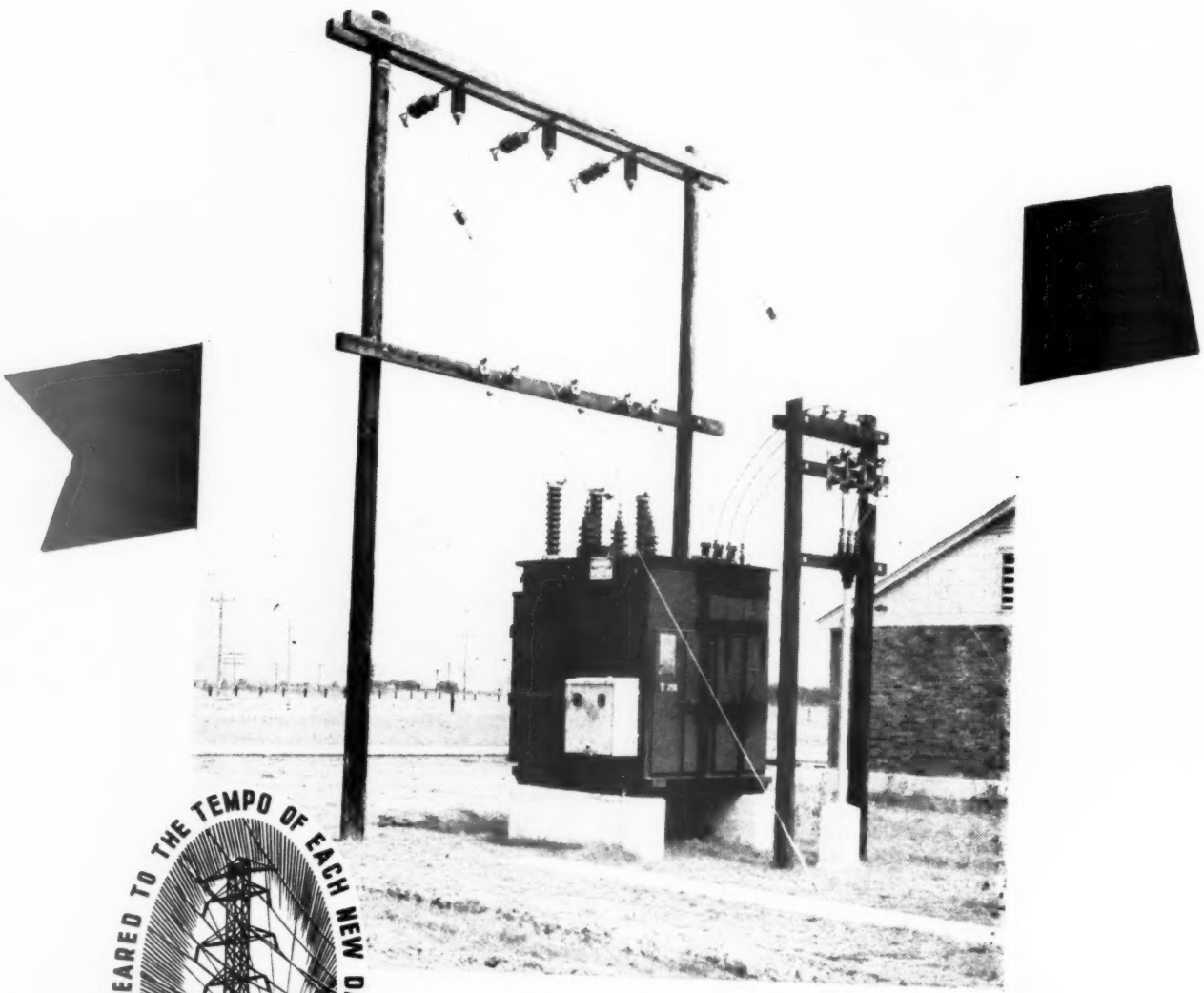
Warren T. Bulla

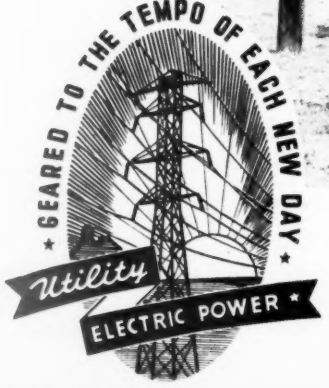
The first consideration bears directly on frequency allocation problems because this factor determines the width of the piece of spectrum space required by each type of transmitter. A transmitter is essentially an a-c generator, which is adjusted to operate on a single frequency called the "carrier frequency." Normally this single carrier frequency does not transmit intelligence. For it to do so, it must either be turned on and off according to a prearranged code (telegraphy), or other frequencies must be combined with it, (telephony, broadcasting, etc.). These latter have the effect of widening the carrier frequency until the combination occupies a band of frequencies extending up and down from the basic carrier frequency. This combination is commonly called a "channel" and its width, although partially dependent upon the carrier frequency, is roughly proportional to the quantity of information that must be transmitted at one time. For example, a telegraph channel can be quite narrow, say 1 kilocycle wide; a voice channel needs to be wider, about 5 kilocycles under an AM (amplitude modulated) system or 40 kilocycles under an FM (frequency modulated) system; a program (music) channel needs to be several times wider than a voice channel, roughly 10 kilocycles under AM and 200 kilocycles under FM; a television channel, which includes both picture and sound, requires a channel at least 6000 kilocycles wide.

It is obvious from this that "channel" is a very flexible term, the variations in which must be recognized when comparing different services. One television channel, for instance, occupies the same spectrum space as do 150 FM voice channels as used by the mobile services.

As a result of fundamental and uncon-

POWER





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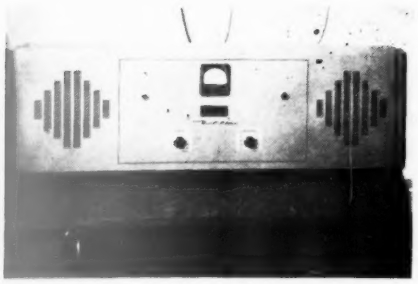

Transmitter, receiver, and speaker cabinet for fixed or central station.

trollable characteristics, frequencies below 30 megacycles are generally used for long range transmissions and channels in this range are internationally regulated, whereas frequencies above 300 megacycles are used for all applications where line-of-sight, point-to-point transmissions are required. Channels in this range are generally available for allocation by national governments without regard to international coordination. The remaining block of frequencies between 30 and 300 megacycles is, therefore, the only portion of the spectrum that is useful for short range applications where line-of-sight conditions do not prevail. Practically all mobile systems utilize channels in this range and the block is presently allocated as follows:

Government	123.5 mc	46 per cent
Broadcast	98	36 per cent
Fixed and mobile	21.5	8 per cent
Aviation	14	5 per cent
Amateur	13	5 per cent
Total	270 mc	100 per cent

Of the 21.5 mc allocated to the fixed and mobile services, the power utilities, (gas, electric, water and steam) have been allocated 1.4 mc or 6.5 per cent (0.5 per cent of the 270 mc total) and this is on a shared basis with petroleum and "other industries."

The 1.4 mc allocated to "Power, petroleum, etc." is located as follows:

6 channels in the 33 mc block	0.24 mc
11 channels in the 75 mc block	0.44 mc
6 channels in the 75 mc block	0.24 mc
3 channels in the 153 mc block	0.18 mc
5 channels in the 158 mc block	0.30 mc
31 channels	1.40 mc

It will be noted that more than half of the channels are between 30 and 40 megacycles where the wave characteristics are such that considerable long range "skip" interference takes place. The characteristics of the 75 mc and 150 mc bands are much superior in this respect, but this advantage is secure at the sacrifice of a noticeable reduction in range of coverage, for waves of the higher frequencies do not bend down into valleys or fill in behind hills as satisfactorily as do those of the lower frequency bands.

To meet varying conditions of terrain and coverage requirements, to minimize the undesirable effects of "skip" interference, and to permit the repetitive use of frequencies at comparatively close geographic separation, it is important that channels in adequate number be available in both the low and the high regions of the 30-300 mc band.

As radio waves may be international in their range, their use must be subject to international regulation in the form of treaties wherein the radio spectrum is divided into blocks of frequencies assignable to the various government and non-government services. The United States delegates to these conferences come under the jurisdiction of the State Department. The current agreement was developed at the Cairo Conference of 1938, and will be superseded sometime in 1949 by one developed this year at the Atlantic City Conference.

As a result of the "Communications Act of 1934" (Sec. 1) creates a Federal Communications Commission to perform, from time to time, certain tasks:

(a) Classify radio stations;

(b) Prescribe the nature of the service to be rendered by each class of licensed stations and each station within any class;

(c) Assign bands of frequencies to the various classes of stations and assign frequencies for each individual station and determine the power which each station shall use and the time during which it may operate;

(d) Determine the location of classes of stations or individual stations;

(e) Regulate the kind of apparatus to be used;

(f) Make such regulations—as it may deem necessary to prevent interference between stations—; Provided, however, that changes in the frequencies,—shall not be made without the consent of the station licensee unless, after a public hearing, the Commission shall determine that such changes will promote public convenience or interest or will serve public necessity—etc.

The Federal Communications Commission is composed of seven commissioners appointed by the president, one of whom is designated as chairman.

The commission at present is composed of the following members:

1. Wayne Coy, chairman
2. Paul A. Walker
3. Clifford J. Durr
4. Rosel H. Hyde
5. Edward M. Webster
6. Robert F. Jones
7. George F. Sterling

The Public Safety and Special Services (under which Power Utility and Petroleum Service is classified) is headed by Glen Nielson. The Frequency Service—Allocation Division operates under the direction of A. L. McIntosh, Chief, who is assisted by L. DeLaFleur.

In November, 1942, J. L. Fly, then chairman of the FCC, suggested that the radio industry set up an organization which might effectively aid the commission in resolving the problems of frequency allocations and system standards which would face it at the end of the war.

As a result the Radio Technical Planning Board (RTPB) was established. The RTPB comprises 13 panels and numerous committees, 68 in all. Panel 13 represents the Mobile and Emergency Services. The panel is composed of nine committees, C4, which is power utilities and C9, which is the petroleum industry.

Committee 4 and Committee 9 made a nation-wide survey of postwar requirements. Based upon these surveys well developed estimates of the channel requirements of the power utilities and petroleum industry were made and plans made to coordinate those needs with those of the other services represented on Panel 13. It was evident at an early stage that no compromise solution would be reached for the reason that the demands for channels far exceeded the *total* supply.

Following this inevitable failure by RTPB, voluminous testimony and data

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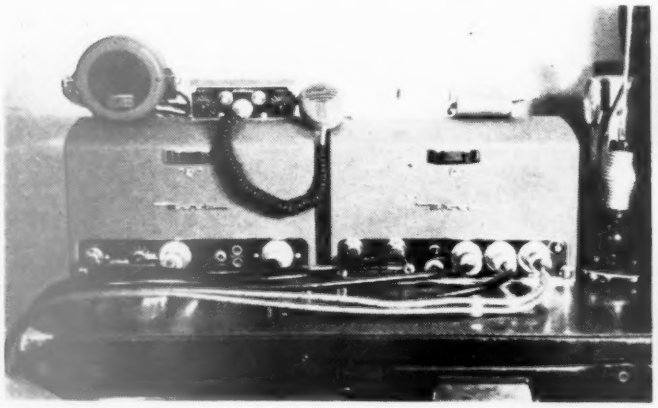
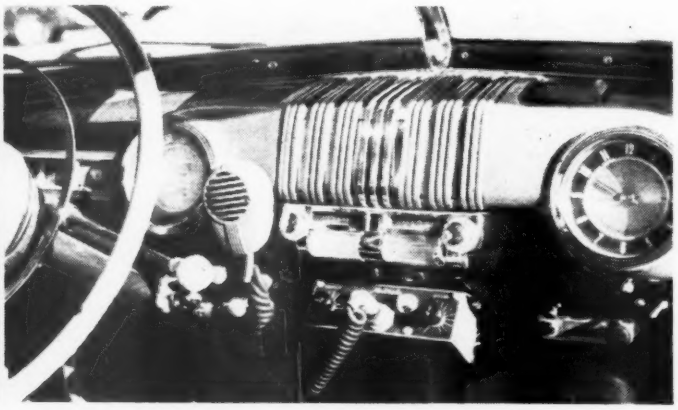
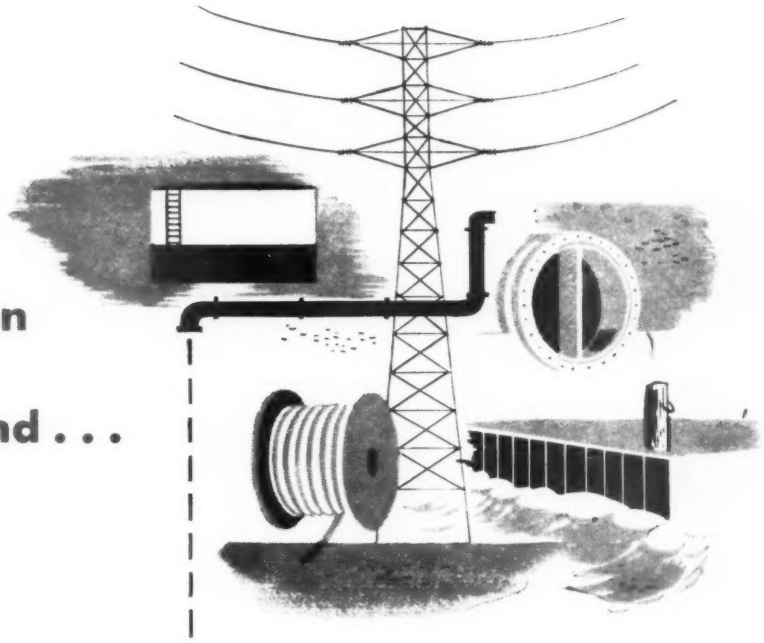


Radio microphone and control panel are easily accessible to operator of vehicle.





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If you have an underground corrosion problem—protecting buried storage tanks or underground piping, for example—you'll find that Magnesium Anodes are the effective—the efficient answer. They are being used in an ever increasing number of commercial installations. That's because they have proved their ability to reduce corrosion to a minimum in a wide variety of applications.

Take a look at some of the important advantages of Magnesium Anodes listed here, and you'll see why they give you maximum protection at lowest cost. High anode voltage, for example, means stored electrical energy is always readily available. Freedom from polarization effects permits continued production of electrical current without interference by corrosion products. These advantages explain the superiority of Magnesium Anodes. And they explain why they're so widely used today. Better investigate Magnesium Anodes for your own installation. Get the facts—write to Dow.

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Why Magnesium Anodes Give You More Protection at Less Cost

1—External power source unnecessary.
2—Equipment maintenance eliminated.
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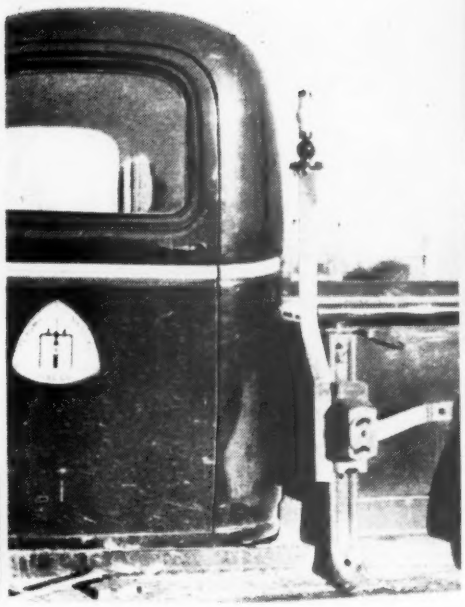
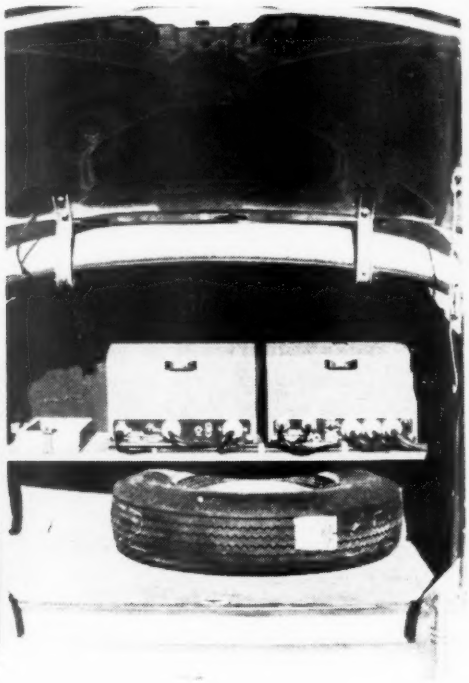
DOW

CHEMICALS INDISPENSABLE TO INDUSTRY AND AGRICULTURE

Transmitting and receiving antenna used with mobile radio on a 30-40 Mc. system.



Antenna and special support as used with a pick-up.



Mobile radio installations showing transmitter and receiver in truck.

have been presented by C4 and C9 in support of their position. Public hearings have been held and some of the commission's decisions have been announced.

To administer the many problems involved in coordinating local frequency assignments both between users within the utility service and with those of petroleum and other services, Committee 4 sponsored the formation of ten regional groups.

In sponsoring the formation of such regional coordination groups, C4 of the RTPB Panel 13 unequivocally assumes a dual responsibility. First, it agrees to determine and pursue such national policies as may be necessary to insure uniformity of action within the power utility group and unity of purpose in negotiations with other service groups and with technical or regulatory bodies. Second, in the interest of developing a workable national frequency assignment pattern, it agrees to act as a coordinating medium between regional groups.

As all frequencies available to power utilities are also available to petroleum pipe line operators, it is highly desirable that potential as well as present licenses of both industry groups be included in any regional coordination organization.

The regional plan constitutes a basic pattern for use as a guide in selecting the most suitable frequency or frequencies for any mobile radio system that is to operate on one or more of the 31 frequencies between 30 and 300 mc presently allocated for use by power utilities, petroleum pipe line operators, and other industries requiring similar radio service.

During the three-year period just ended, the use of radio by the power utilities grew at a very rapid rate. In round figures the story is as follows:

Date	Permittees	Transmitters
September, 1944	55	850
May, 1945	120	1,800
May, 1946	240	5,000
May, 1947	310	8,400
December, 1947	415	13,000

Thus FM (frequency modulation) continues to demonstrate its value to industry, because most new installations are FM. Operating in the higher frequencies of the radio spectrum, FM is noted for its tonal quality and offers comparative freedom from static and other interference.

That portion of the frequency spectrum 30-300 mc in which the present 31 channels now assigned to power-petroleum is as follows:

Present—33.18, 22, 26, 30, 34 and 33.38.
37.46, 50, 54, 58, 62, 66, 70, 74, 78, 82 and 37.86.
75.42, 46 and 75.50.
75.54, 58, 62 and 75.66.
153.59, 65 and 153.71.
158.01, 07, 13, 19 and 158.25.

In addition to these there are some of the old special emergency frequencies and provisional and experimental frequencies available upon proper showing and in which a number of utilities and pipe line companies have transmitters in service.

A number of radio manufacturers are presently manufacturing transmitting and receiving apparatus, particularly suitable for the service requirements of power utility and petroleum companies. Modification and improvement in present designs will come about as the usage spreads, so that manufacturers know more about the job to be done.

I doubt the necessity of pointing out the many applications and benefits of mobile radio, all that is necessary is to consider the mobile crews and personnel and to calculate the advantages of being able to contact them immediately when their transportation equipment is within range of a transmitter station or another radio equipped mobile unit; the possibility of dispatching repair crews to augment or restore facilities that have failed; and service in relation to preservation of life and property in emergency conditions.

It is hoped that if the demand for radio service is sufficiently great manufacturers can produce this equipment in quantity and lower equipment costs can be expected.

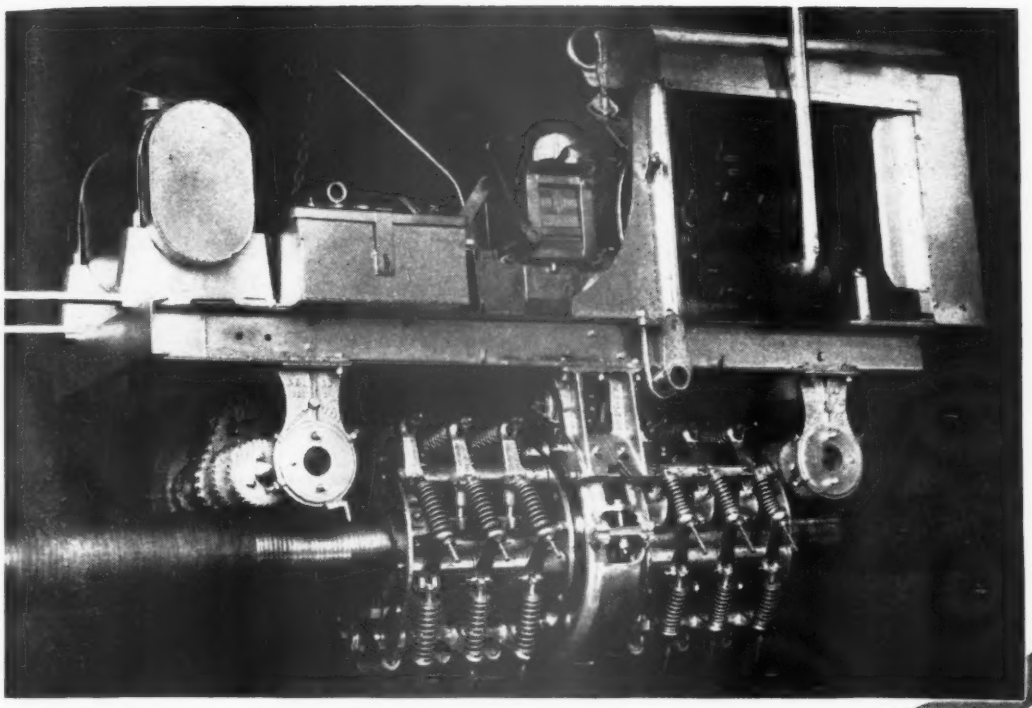
Presently estimated costs for installations will approximate as follows:

Pack sets (Walkie-Talkie type)	$ 200 to $400 each
Mobile units	$ 500 to $750 each
Portable units	$ 300 to $1,000 each
Fixed stations	$1000 to $10,000 each

There are a number of service companies being established for the maintenance and servicing of radio systems, thus eliminating the need for the user to set up a service department for this work, although many utilities and pipe line companies already have a communication service department that can readily adapt itself to look after such installations.

Prospective users would benefit by contacting the Regional Coordinating Group in their area and procuring a copy of the rules covering their service from the FCC, from both of whom much information and assistance will be derived.

★ ★ ★



● *Built by* W-K-M CO., INC.

PIPE cleaner for oil!

Of all the places you find SKF Bearings in the oil industry, this W-K-M Traveling Type Pipe Line Cleaning Machine is one of the most unusual. This machine travels along the pipe line under its own power. Its rotating heads—containing cutter wheels, wire brushes, and other cleaning elements—thoroughly clean and descale both new and old paint, preparatory to the application of priming paint, hot coating and wrapping material. Its SKF Bearings give the same smooth, continuous, and economical performance that led to the widespread use of SKF Bearings on compressors, countershafts, crown blocks, draw works, drilling rigs, etc. No matter what kind of job you have for a bearing, remember this: SKF puts the right bearing in the right place. 6410

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

P 615.635

Corrosion prevention begins with construction

By WM. E. HUDDLESTON, *Consulting Engineer*

PLANS and specifications for the laying of a new pipe line should include provisions for systematic insulation of the line during construction. The insulating procedures may be carried out at nominal cost, and very good economy will be effected through the reduction of initial corrosion tendencies on the completed line and through more effective and lower cost cathodic protection that may be installed a few months after completion of the pipe line.

EXCLUSIVE

Rigid coating specifications are generally observed throughout the construction of a new pipe line, a practice that is almost universally accepted by pipe line operators. With the small amount of additional planning needed to provide for insulating during construction and installing cathodic protection at a later date, the pipe line may be maintained entirely free from external corrosion and at exceedingly low cost.

● **Plans for insulating.** The insulating procedures outlined in this article apply to the general run of transmission pipe lines. Certain exceptions require special consideration as, for example, in the case of pipe lines that are to be laid in areas in which electrolysis is a factor. In general, however, the new pipe line should be insulated according to the following plan:

(1) Insulate the extreme ends of the new pipe line. This will prevent electrical contact with all dissimilar structures such as yard piping, manifolds, foreign pipe lines, gathering lines, wells, storage tank bottoms, etc. Otherwise, scattered pipe line corrosion will immediately become active due to the galvanic potential

The Author

Wm. E. Huddleston, pipe line corrosion consultant, has had 16 years of pipe line experience, 12 years of which have been devoted entirely to the prevention of external corrosion. He was graduated from the University of Nebraska in 1930 with a B.S. degree in electrical engineering. During the last four years he has supervised the installation of cathodic protection on approximately 3000 miles of pipe lines. His firm is Huddleston Engineering Company, Bartlesville, Oklahoma.

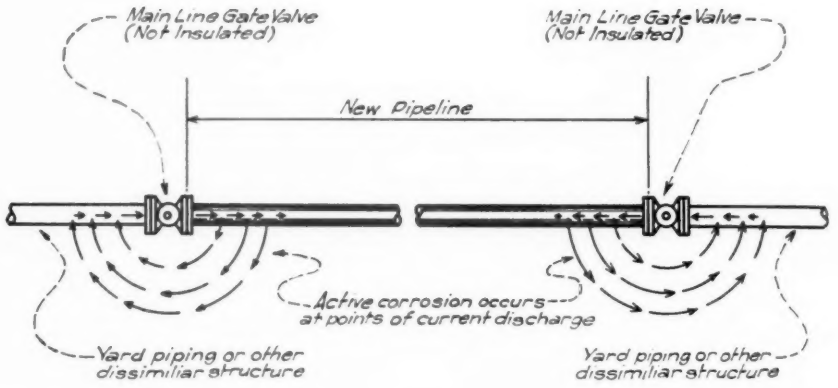

Main Line Gate Valve (Not Insulated)
Main Line Gate Valve (Not Insulated)
New Pipeline
Active corrosion occurs at points of current discharge
Yard piping or other dissimiliar structure
Yard piping or other dissimiliar structure

FIG. 1. Occurrence of scattered corrosion along a new pipe line because of interaction between two connecting dissimilar structures. The main gate valves should be insulated, or insulating flanges should be installed to prevent this type of corrosion.

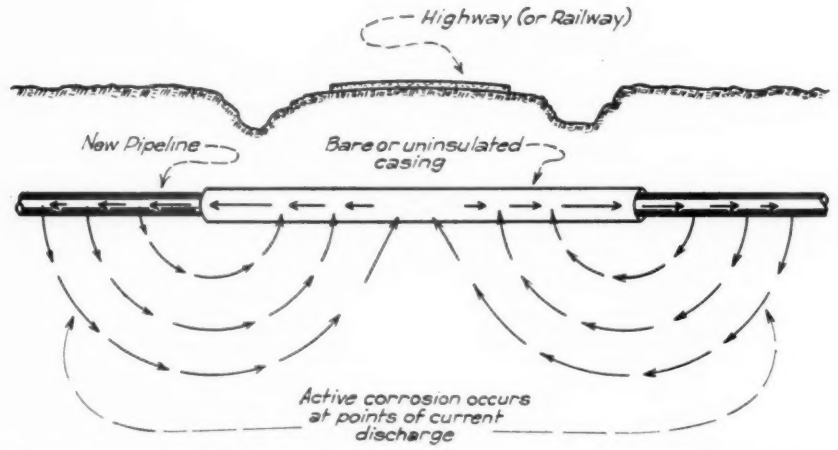


FIG. 2. Corrosion setup on a new pipe line because of interaction with bare or uninsulated casing. The casing should be coated or insulated from the pipe line.

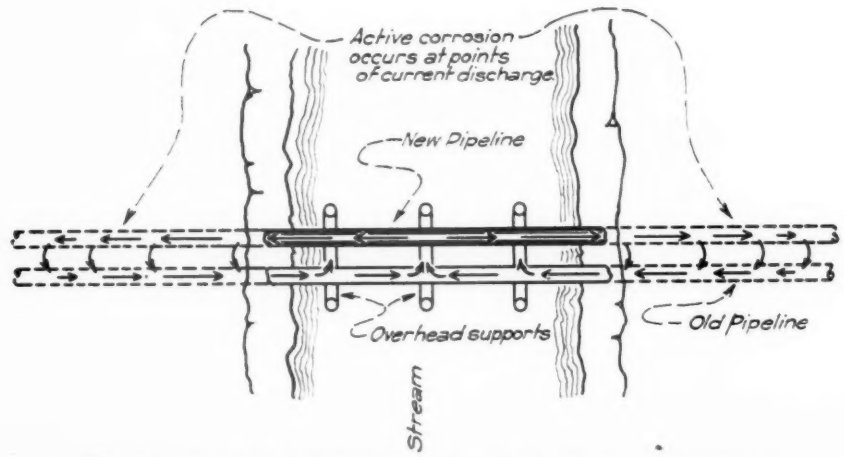


FIG. 3. Excessive corrosion on a new pipe line caused by interaction with a dissimilar line in contact with a common overhead support.

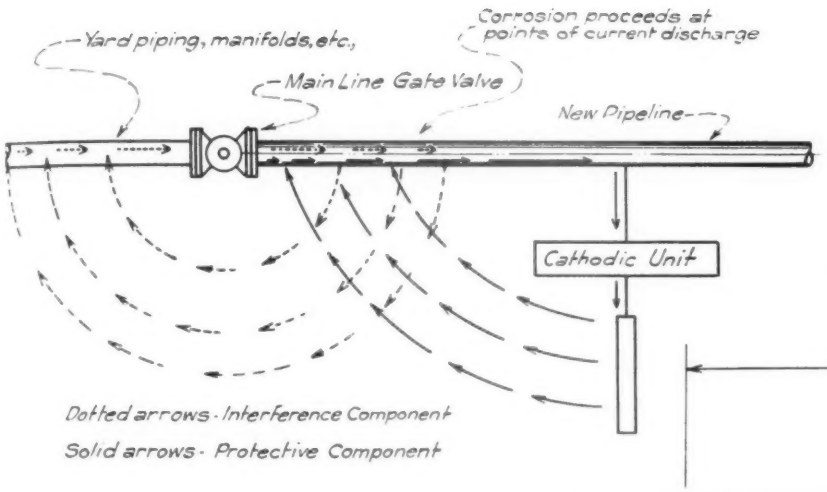
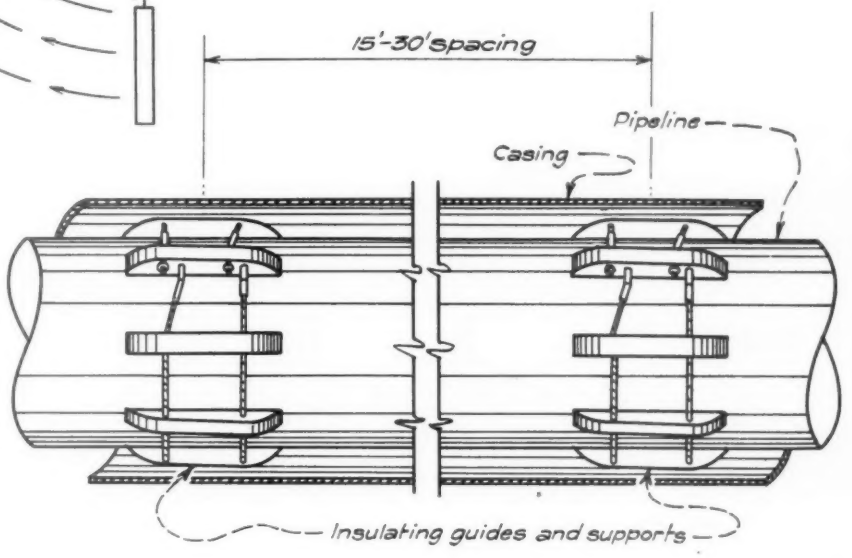

Yard piping, manifolds, etc.,
Corrosion proceeds at points of current discharge
Main Line Gate Valve
New Pipeline
Cathodic Unit
Dotted arrows - Interference Component
Solid arrows - Protective Component

FIG. 4. Illustration of the manner in which a cathodic unit may fail to suppress localized corrosion on an uninsulated pipe line.

FIG. 5. Casing guide and insulator.



that will prevail between the new pipe and the oxidized surfaces of the older piping. (See Fig. 1.)

(2) Insulate or coat all casings. This will eliminate the formation of multiple corrosion cells over portions of the completed pipe line, as illustrated in Fig. 2.

(3) Insulate the new pipe line at common overhead crossings or at any other locations at which the line may contact other pipe lines. Fig. 3 shows the manner in which a new pipe line may be subjected to severe corrosion attack because of the contact establishd with another pipe line on a common overhead supporting structure. In this illustration a large corrosion cell is established whereby two pipe lines function as the two active electrodes, with the result that the new pipe line will corrode in widely scattered areas and at moderate to excessive rates. Many pipe line leak repairs can be avoided under these conditions by insulating properly.

● **Avoiding interference.** In addition to preventing excessive local corrosion, the insulation of a new pipe line will oppose the inception of interference currents. This will eliminate a substantial amount of bonding that otherwise would be required when the line crosses foreign carriers that are operating under cathodic protection, and it will facilitate more economical and more effective results when cathodic protection is later installed on the line.

Fig. 4 illustrates the manner in which a cathodic unit may fail to suppress an interference current component on an uninsulated pipe line, although the protective unit may have been over-designed in an attempt to preclude these sources of corrosion trouble.

● **Insulating by coating casings.** In event that it is considered desirable to insulate at casings by simply coating the casings before they are pulled into their permanent positions under highway, railroad, and other important crossings, it is suggested that a single application of coating be applied. It is not usually thought necessary to have an eminently good coating job for this particular type of service, and, accordingly, hand cleaning and coating casings of average length is considered acceptable practice.

FIG. 6. Insulating seal and bushing.

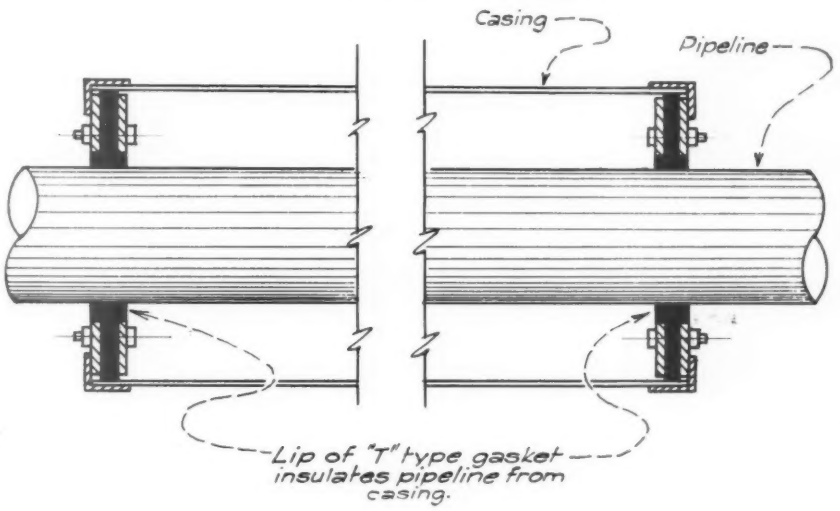
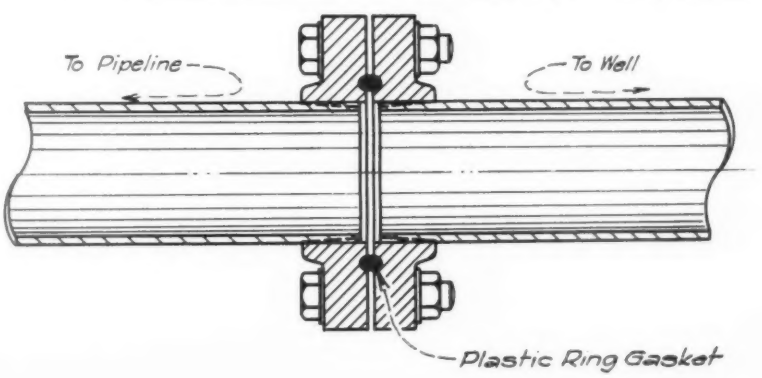
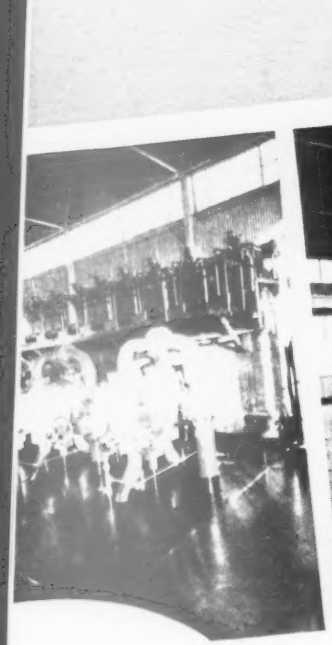


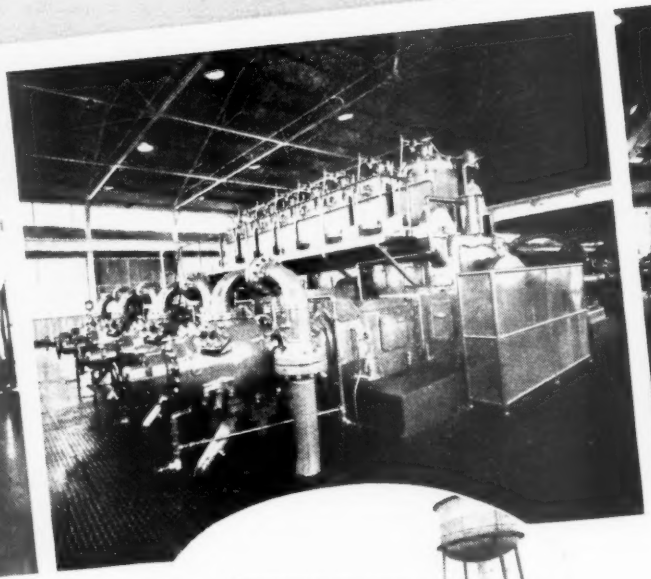
FIG. 7. Insulation of HP flange on wells using a plastic ring gasket.

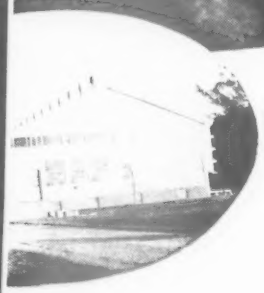


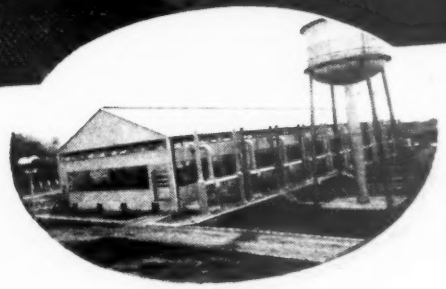
ON THE PANHANDLE EASTERN PI

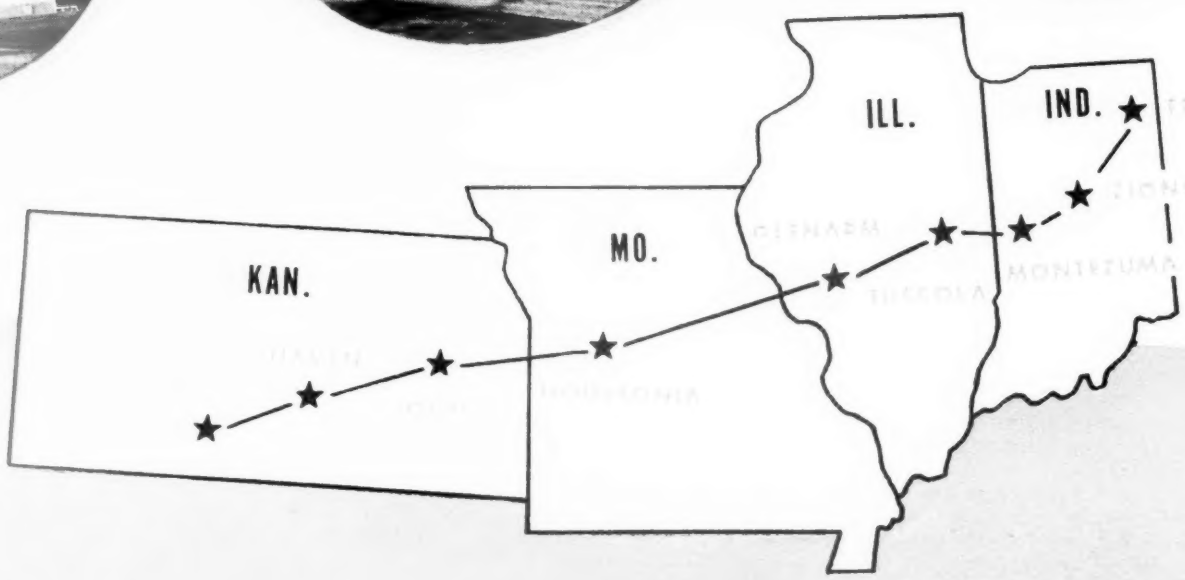
Clark "Big Angles" b



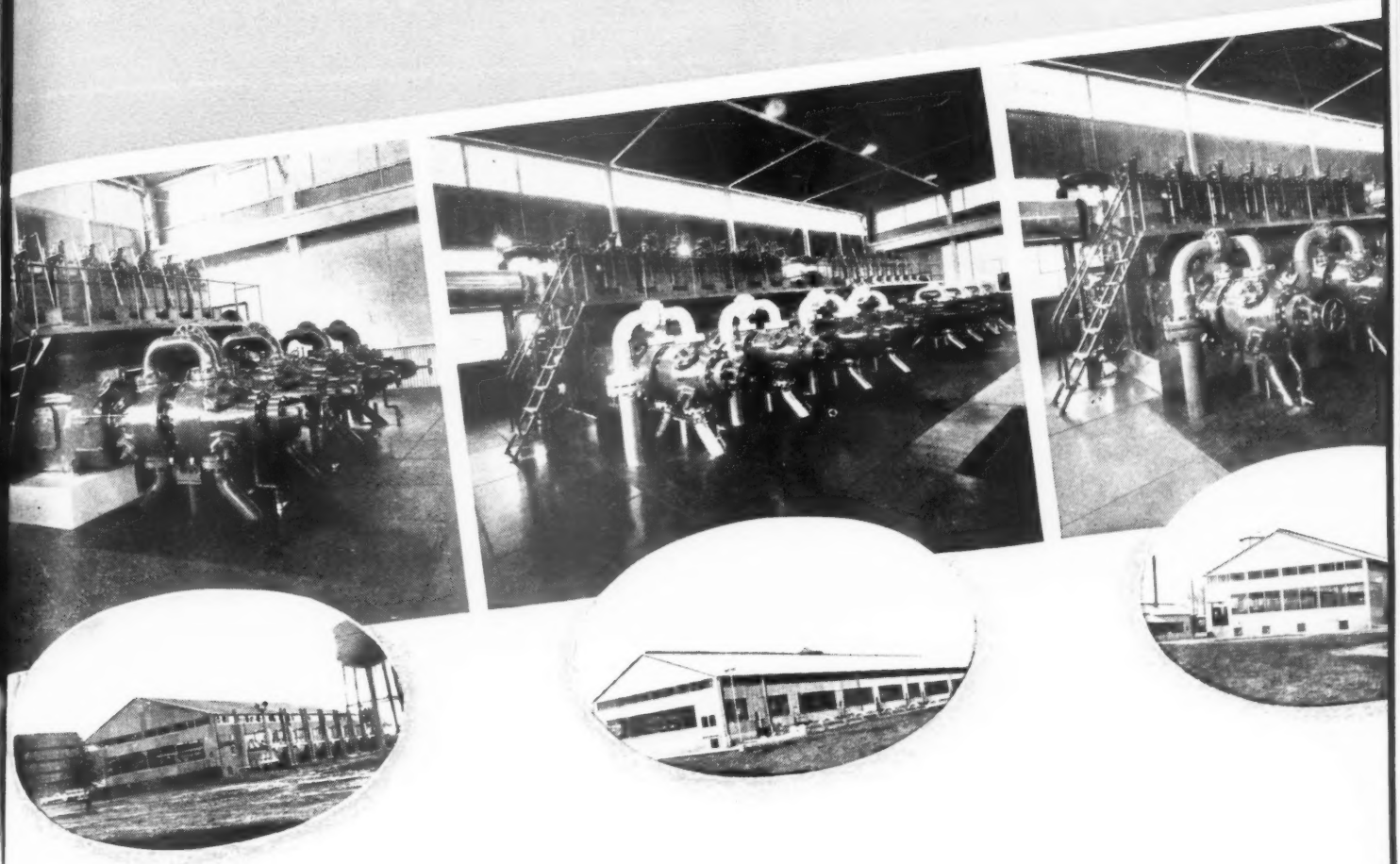








PIPE LINE boost gas in 9 stations



● In 9 compressor stations along the Panhandle Eastern Pipe Line, Clark "Big Angles" are performing gas booster service. Thirteen of these powerful 1,600 B.H.P. engine-compressor units supply a total of 20,800 B.H.P. to the line.

Six of the 9 stations are illustrated here. Others not shown are at Tuscola, Ill., Olpe, Kansas and Greensburg, Kansas. Clark "Big Angles" are highly favored everywhere for pipe line service. In addition to their dependability and economy of space, they are particularly notable for the accessibility of all parts for easy maintenance.

Furnished in 5, 6, 8 and 10-cylinder sizes, 1,000 to 2,000 B.H.P. Write for descriptive Bulletin "B-A 17".

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CLARK

ONE OF THE DRESSER INDUSTRIES

SETS THE PACE IN COMPRESSOR PROGRESS

Industry beats the oil shortage

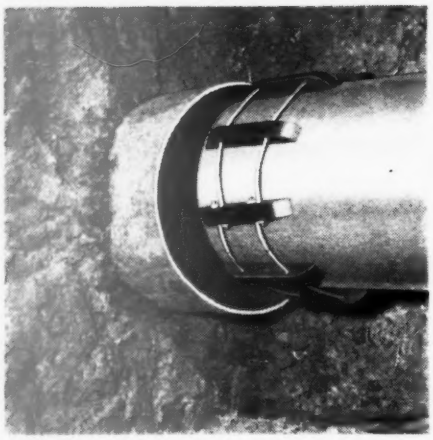
The petroleum industry took care of the fuel shortages this winter, Claude V. Barrow, oil editor of *The Daily Oklahoman*, told the Oklahoma Utilities Association at its annual meeting.

"The petroleum industry buckled down and took care of the situation . . . just as it always has and always will if permitted to operate as a free enterprise," he said.

A number of writers have commented on the extraordinary job performed by the industry in one of the worst winters on record. Although large shortages were predicted, they point out, actually supply almost met the greatest demand of fuel oil in history. With only slightly better facilities, the shortage propaganda would have fallen completely flat.

Keith Fanshier, *Chicago Journal of Commerce*, warns, however, that the industry faces a new problem of adequate gasoline supply and distribution to power the largest motor vehicle registration in history.

PROTECT YOUR COATED PIPE LINE IN RIGHT-OF-WAY CASINGS



Williamson Pipe Line Casing Insulator*

This device—simple, rugged, economical—supports and guides the leading end of coated line pipe into the right-of-way casing under railroads and highways.

Additional Casing insulators, clamped around the pipe every 20 to 30 feet, serve three purposes:

1—To protect the pipe coating.

2—To act as pipe skids, facilitating installation.

3—To separate pipe and casing, assuring permanent insulation for cathodic protection.

WmSEAL Style B-20 CASING BUSHING*

Equipped with exclusive T-gasket for positive water-tight seal and insulation of pipe from steel flanges, this improved "casing sleeve" is designed for easy installation at each end of pipe-line casing under right-of-way crossings.

WmSEAL Casing Bushings are readily installed because they offer:

- Large center hole for loose fit around coated pipe.
- Generous clearance inside of casing before bolts are tightened.
- Quick opened after removal of only one bolt, for closing around installed pipe line

WmSEAL Casing Bushings are widely used as wall sleeves for valve boxes, manifolds, etc.

*Patents Pending

THE PIG WITH THE POKE CLEANS PIPE LINES

T. D. Williamson, Inc.

TULSA 9, OKLAHOMA

It is conceded that 100 per cent coverage will not be attained by hand coating even with reasonable effort and skill, and it is also conceded that a portion of the coating will be scraped off the casing as it is being pulled into place. With a reasonable amount of care, however, the coating on at least 90 per cent of the casing area should be intact after the casing has been pulled into position, and for all practical purposes this is considered adequate for this particular service.

● **Insulating at casings with special insulators.** In many cases pipe lines can be insulated from the casings more economically by using casing insulators that are made exclusively for this purpose. If such insulators are used it is seldom necessary to coat the casings.

Fig. 5 illustrates a type of insulator that serves as a guide to center the pipe as it is being pulled through the casing, thereby protecting the pipe coating. The required number of such insulators may be spaced along the pipe to support and center the pipe at proper intervals to prevent contact within the casing. This type of insulator is especially desirable for centering pipe in casings in which welding sleeves are used over the pipe welds within the casing.

Another type of casing insulator is shown in Fig. 6. This device serves to seal the ends of the casing as well as to insulate the pipe from the casing. A full opening hinge permits easy installation, and provisions are made to allow for expansion and contraction of the pipe line.

● **Insulating wells.** In certain cases it might be desirable to include gathering lines in the protective system with the transmission line, in which case it would be necessary to insulate the wells from the gathering lines. Regardless of the plan that is used for protecting the various lines, however, it is generally considered good practice to insulate all well structures from their connecting field lines.

Well structures may be insulated by installing an insulating ring gasket in a high pressure flange, as shown in Fig. 7, using the conventional method of insulating the flange bolts. Some gas pipe line operators make it a standard practice to insulate the flanges on the wing gate in accordance with this plan. The insulating gasket shown in this drawing is designed for a very high compressive strength, and because of its insulating qualities, it affords protection against local galvanic corrosion at the joint.

● **Conclusions.** The complete insulation of pipe lines during construction affords the following advantages: (1) A substantial amount of corrosion that would otherwise be set up along the pipe line due to galvanic action will be eliminated; (2) the inception of stray currents will be opposed, which will further reduce the corrosion tendency; (3) after having eliminated the above described sources of trouble, the pipe line may be maintained entirely free from external corrosion at very low cost, using a moderate amount of cathodic protection.

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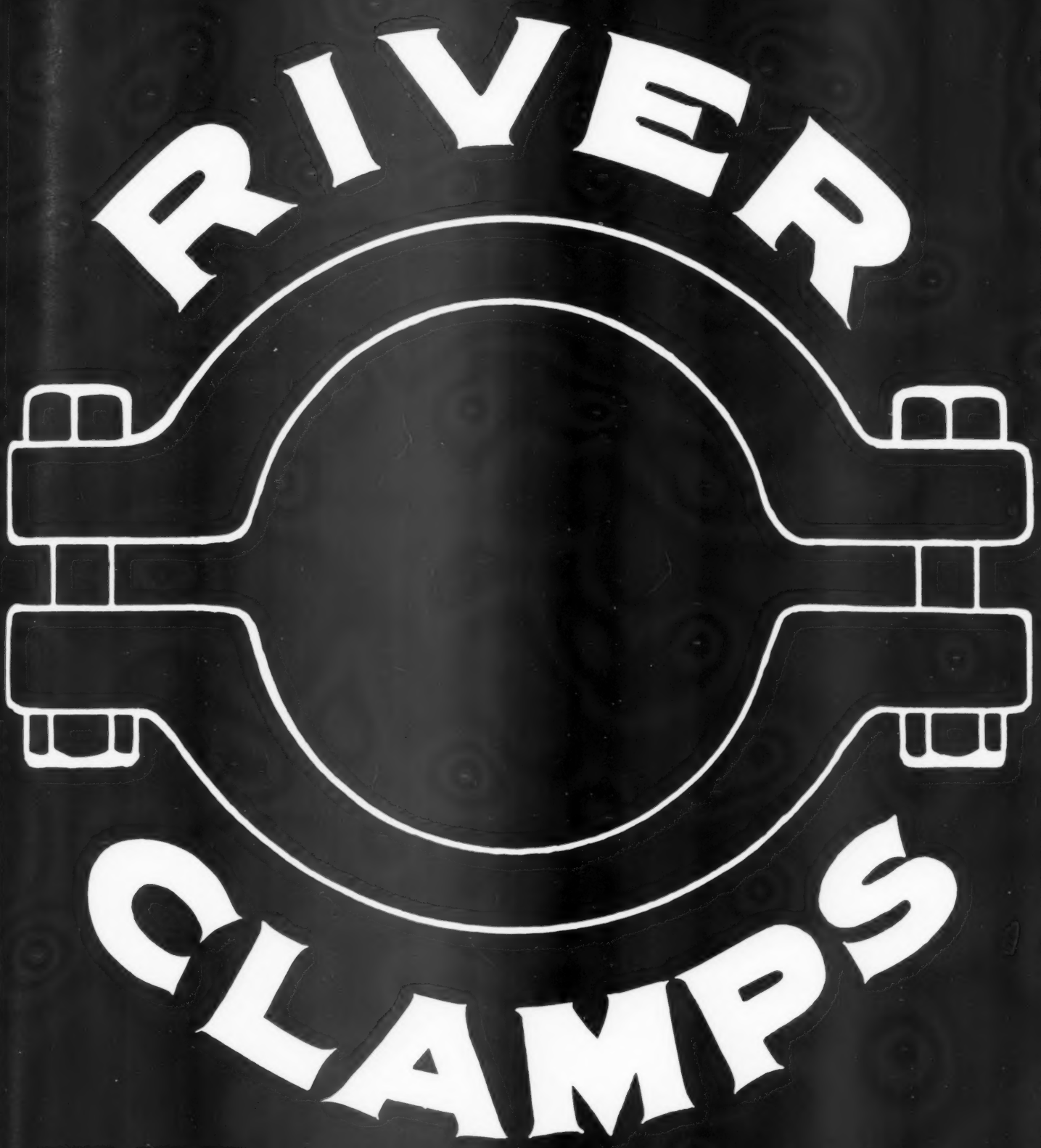

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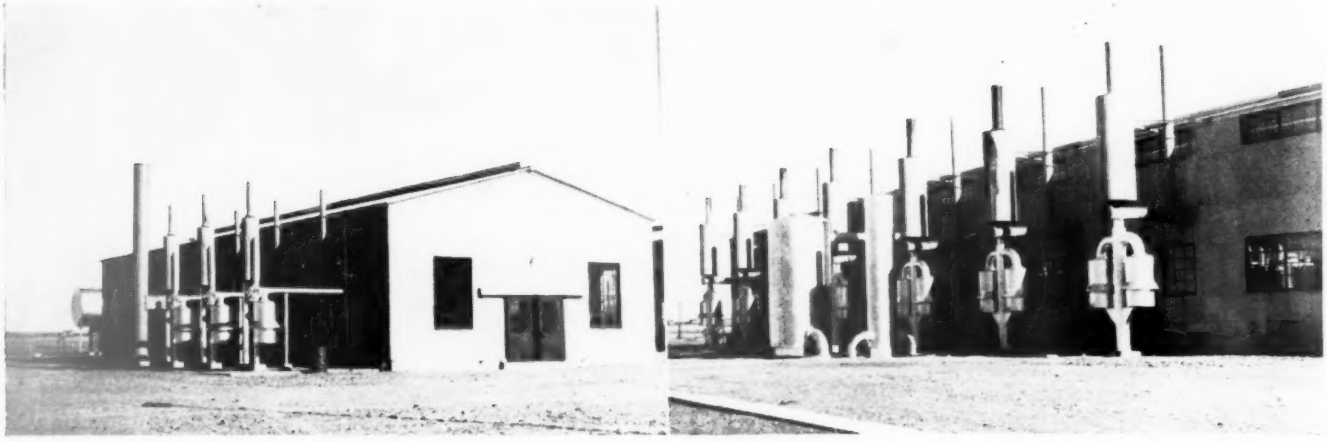


Generator building is at left with exhaust silencers, air intake cleaners, and boiler stack. At right is compressor building with its line of exhaust silencers, air intake cleaners, and jacket water surge tanks.

New compressor station is latest design

By HAROLD F. DAWE* and W. H. GOONTZ*

IN 1947 The Colorado Interstate Gas Company placed in operation an entirely new natural gas transmission line of 20 in. diam to supply natural gas to Denver, Colorado, and to serve as a feeder line for additional gas supply to northern Colorado and southern Wyoming cities. The line has an approximate length of 250 miles and transmits gas from the Kansas Hugoton field.

EXCLUSIVE

The line has one compressor station near Lakin, Kansas, on U. S. Highway No. 50 installed in 1947, which boosted the natural field pressure sufficiently to supply 100,000,000 cu ft a day through the pipe line. The compressor station has the latest and most modern practices in compressor station design, and includes a solid adsorbent dehydration plant. The dehydration plant is designed to produce a dew point of approximately 25 F in the gas entering the line.

● **Compressors.** Seven 1200-hp vertical angle type compressors are installed. These engines are each equipped with four 7¾ in. diam by 17 in. stroke compressor cylinders and are arranged with clearance pockets to compress gas with suction pressure varying from 220 to 250 psi to a discharge pressure of 600 to 900 psi.

Representative of capacities is the following:

Suction pressure	Discharge pressure	Unit capacity, cfd
220	900	13,400,000
220	600	17,800,000
250	900	14,800,000

*Stearns-Roger Manufacturing Company.

The machines are placed at 90 deg to the axis of the compressor building, which is 192 ft long by 34 ft wide of steel frame and covered with corrugated asbestos-cement board.

A soil investigation was made before any foundations were designed and it was determined from the borings that the sub-surface had an excellent load bearing quality. No difficulty was encountered at any time and no special measures were necessary to stabilize foundations. The compressor station site is naturally well drained at all times, due to the gentle slope to the south. The compressors are installed on an 18-in. reinforced concrete mat, which serves to support the building walls and provides a floor for the basement. The basement is deep enough to provide 7 ft clearance under all overhead pipes and is large enough to completely contain all water, fuel gas, and air lines, the oil reclaimers, and dirty oil tanks. An operations entrance to the basement is provided from the main floor about midway of the building, and two exits from the basement to the outside are provided. One end of the compressor building has been made of cinder blocks to allow for future expansion.

Each engine has one heavy duty uninsulated exhaust silencer and two air cleaners. The air cleaners and exhaust silencers are mounted on the air intake line in an unique arrangement that provides an explosion head in the exhaust line at the muffler base. Expansion bellows are placed in the exhaust lines to reduce thrust on the engine exhaust manifolds. Each exhaust line is jacketed and an external stack provides air circulation to remove the heat from the building. The exhaust line jackets are insulated principally to reduce the drumming noise encountered in the exhausts.

The main gas is carried in a 20-in. suction header pipe along one side of the compressor building and each engine is served with a 10-in. suction line with a large suction bottle at the cylinders. The compressor cylinders discharge into a large volume bottle mounted below the cylinders and acts through the leads to the individual cylinders by means of jacking screws to support the cylinders. The discharge volume bottle has a pulsation absorber designed into it and a 10-in. discharge line carries the compressed gas through a horizontal expansion bend into a 20-in. discharge header. The suction and discharge of each machine are arranged so that a bypass may be used to equalize the suction and discharge pressures. A vent is also provided to unload the gas from the engine. Safety relief valves are provided on the engine discharge. Vents and reliefs are manifolded onto a vent line and the line is carried to a stack well away from the compressor building. An elevated walkway is placed on one side of the building so as to clear all lines and provide a convenient and safe way of getting to the suction and discharge block valves at each engine.

The compressors have been laid out for future expansion and flexibility. The present station may be increased to a

Another Important Gas Compressor Station and Gas Dehydration Plant Completed . . .

Stearns-Roger is proud of its part in bringing additional natural gas to Denver

We engineered, designed, and completely constructed the 8400 HP Gas Compressor Station and Gas Dehydration Plant at Lakin, Kansas, for Colorado Interstate Gas Company. This station brings 100,000,000 cu. ft. of natural gas daily into Denver. It is designed to discharge at 900 lbs. per sq. in. into the main transmission line.

The dehydration plant—solid dessicant type—depresses the gas dewpoint, thus providing protection against winter ground temperatures of the Rocky Mountain region.
The installation is protected from undue vibration and pulsation by Stearns-Roger Puls-D-Fiers.
Stearns-Roger Dust-D-Fiers completely clean the inlet gas.

Our service was one of UNDIVIDED RESPONSIBILITY: *Design* by our own engineers; *Manufacture* of special equipment in our own plant; *Field Construction* by our own crews and facilities—a complete job from selected site to an operating station.

Stearns-Roger

THE STEARNS-ROGER MFG. CO. DENVER COLORADO

total of 24 engines utilizing the future planned layout.

● **Gas cooling.** All high pressure gas lines are carried above ground on concrete piers. The 20-in. main discharge gas line runs to the cooling tower where the gas enters 14 atmospheric sections. The sections are connected into seven parallel banks of two sections each. The sections are designed to cool approximately 100,000,000 cu ft a day from a maximum temperature of 250 to 80 F. The cooled gas flows from the cooling tower through a gas scrubber and thence to the dry adsorbent towers of the dehydration plant.

● **Cooling tower.** The cooling tower is of the induced draft type with a 12-bay coil shed and two-cell towers. The two fans are driven by 40-hp two-speed motors and operate by manual control.

Cooling water makeup is automatically maintained and a recording meter enables control of the tower blowdown. A system of cooling water treatment to control algae and scale has been established under supervision of a reputable water treating concern.

The water supply is obtained from two 225 gpm water wells about 170 ft deep. The water obtained is good in all respects for cooling water in both towers and jackets and with proper control is not expected to cause any difficulty. Cooling tower spray water is circulated by use of two vertical turbine pumps of 2260 gpm capacity each and driven by 50-hp motors, with a standby unit. A hoist is provided over the pumps to enable easy maintenance. Double sump screens are installed between tower basin and pump sump.

● **Cooling water system.** The cooling water setup incorporates two separate cooling water systems. Due to the fact that dry cooling is feasible in the locality, plus the desire to design as much cooling out of the cooling tower as possible, it was decided to cool the water supplying the power cylinders in a dry type cooler. This system is known as the "hot" jacket water system.

The "hot" jacket water circulates through the compressor engine cylinder jackets and electric generator engine cylinder jackets in parallel and into the dry cooler. The entering water to the engines is desired to be 140 F and the circulation is designed to effect a 10 F rise under normal conditions. The dry cooler has been sized to cool the water under 90° ambient air from 154.5 F to 144 F. Advantage is taken of the reduced station load in warm weather to maintain adequate cooling on the operating machines.

The dry cooler has three 40-hp two-speed fans forcing air over the finned tubes containing the water. The fans are controlled by temperature switches in ten steps from 137 F to 150 F and operate at fast, slow, or stop as determined by the temperature. In cold weather with towers of this type, it has been found difficult to keep the temperature of the jacket water sufficiently high even with dead fans without cutting off coils and decreasing circulation. Under such conditions freezing often results with damage to the coils. To overcome this, both ends of the dry cooler structure were closed off and 12 overhead rolling steel doors were installed. These doors can be completely closed down to cut off all natural draft and provide control not otherwise possible. In addition, a large pneumatically controlled bypass valve is installed across the inlet and outlet headers to the cooler and is controlled by a recording temperature controller located in the compressor room.

The hot jacket water is circulated to the compressors and generators through a 24-in. line by means of two operating horizontal centrifugal pumps driven by 75-hp motors. One spare pump is provided and future room is provided for a fourth pump. A low water pressure alarm horn and light is provided in both the generator room and compressor room to warn the operators. The water from the compressor jackets flows upward away from the engines into an overhead line that discharges into a 10-ft diam by 20 ft high surge tank. Any collected air or gas is released at this point. The pumps take suction from the bottom of the tank.

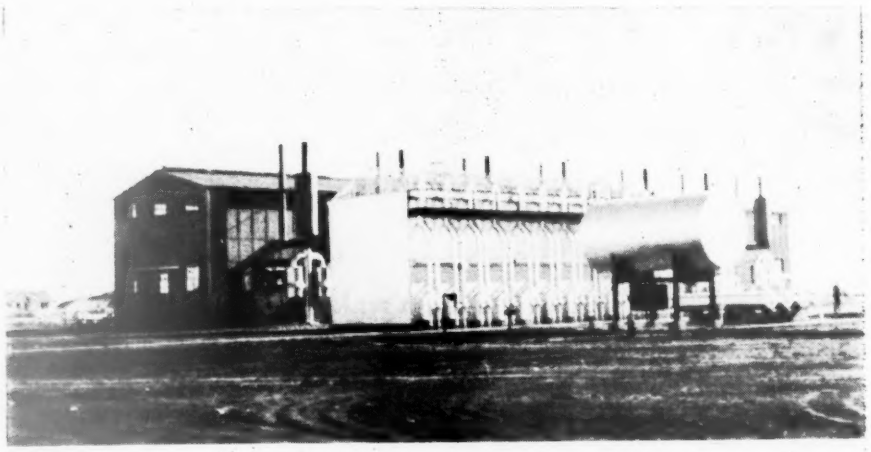
The second system used is termed the "cold" jacket water system and supplies 100 F water to the oil coolers. From the oil cooler the water flows in series through the compressor cylinder jackets where it attains a temperature of about 118 F. The water flows through into a 4 ft diam by 20 ft surge tank where any entrained gas or air is removed. The cold jacket water pumps, which take suction from the surge tank, are horizontal centrifugals driven by 25-hp motors. There are two pumps provided, one as spare, with room for a future pump. These pumps discharge into six atmospheric sections connected into three parallel stacks of two sections each, situated in the cooling tower. A pneumatically controlled bypass valve across the inlet and outlet headers is provided to control the temperature. This bypass valve is controlled by a temperature recorder controller in the compressor room.

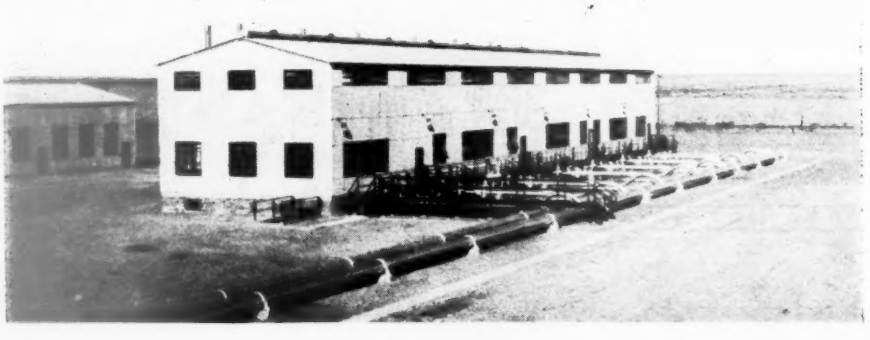
A 40,000 grain zeolite softener is installed in the compressor room basement to treat all make-up water to either the hot or cold jacket water system.

● **Electrical power system.** Electric power is generated for the station power and light requirements by three 6-cylinder in line, 410-bhp, 450-rpm, 4-cycle gas engines driving 352 kva, 282 kw (0.8 PF), 480-volt, 3-phase, 60-cycle, 450-rpm generators with belt driven 7½-kw top mounted exciters.

The generators feed into a three generator panel control board. The switchboard also includes two feeder panels

The hot jacket water is cooled in a dry type aerial cooler. The view at the top shows the end walls of the unit are closed in and the steel overhead rolling doors are shut down. The fresh lube oil tank is in the foreground. Below is the compressor building showing gas piping and elevated walkway.





Presenting

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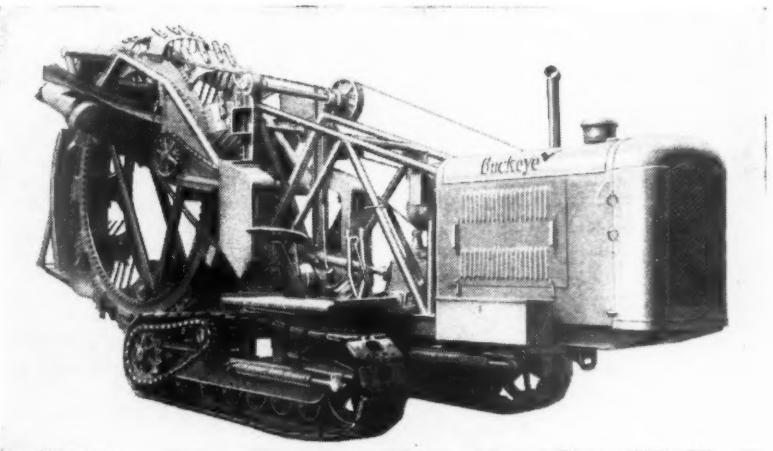
Mighty successor to the famous Model 48—can handle bigger than "the biggest" pipeline jobs—cuts ditch up to 50" wide, 8½' digging wheel depth—110 h.p. diesel power at 850 r.p.m.—32 tons of long-lived, irresistible digging power. Proving-ground tested improvements from stem to stern. The experience of two well-known equipment building organizations, Gar Wood and Buckeye, is apparent throughout. Ask for complete specifications.

The Buckeye Model 312 Pipeliner

Successor to the popular, hard-working Model 12—Cuts ditch 16" to 30" wide (depending upon buckets) and to 6' depth. Digging wheel supported by rugged tubular frame. 67 h.p. diesel power at 1600 r.p.m. Greater range, simplified controls, better balance. Built throughout for longer service, faster digging, cutting costs. Ask for complete specifications.



GAR WOOD INDUSTRIES, INC.

Findlay Division

FINDLAY **OHIO**

Buckeye

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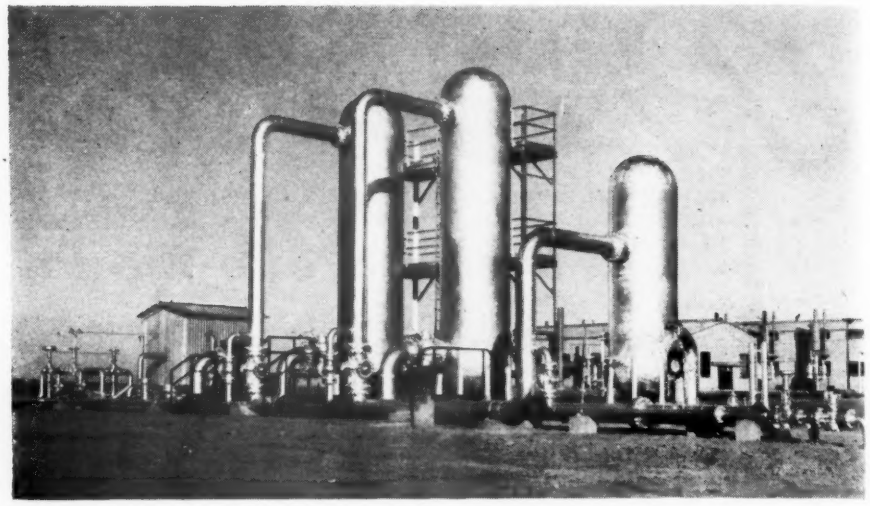
and a swinging synchronizer panel. The switchboard is semi-enclosed and is further protected by an expanded metal guarded enclosure. A cable vault covered by checkered floor plate is provided at the rear of the switchboard for ease in making connections and maintenance.

Starters are provided at all except the largest motors. Where economy and efficiency are indicated, separate power control stations have been provided. All systems are underground in fiber duct or conduit and distribution is made through cable vaults.

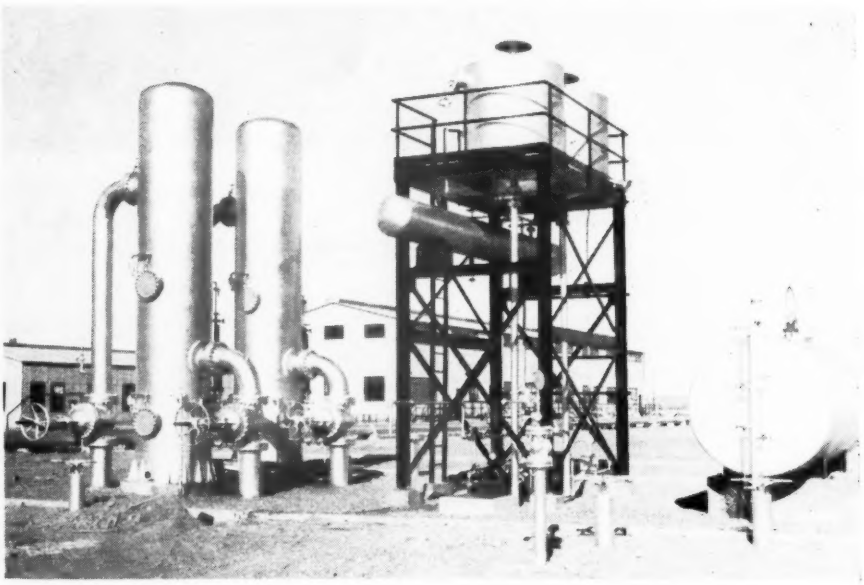
The compressor and meter buildings are provided with explosion-proof electrical equipment for power and lights, all other buildings and equipment are conventional. Buildings are designed with a high illumination level and special attention has been given to adequate lighting for all outside equipment. Electrical energy for the large camp is provided through a 480-volt underground system to the camp area where it is transformed and distributed.

● **Fuel gas system.** Fuel gas for the station is undehydrated gas and is taken from the suction side of the station on the station side of the gas scrubbers. Fuel gas is metered through two 6-in. metering runs in the meter building. The gas is reduced from a maximum of 400 psig to metering pressure of 25 psig through a double ported pilot operated regulator installed in each run. In order to avoid difficulty due to hydrate formation, the fuel gas is passed through a finned tube heater prior to the regulators. The heater is supplied with jacket water off the hot system and use is made of the same water to heat the meter building through electric motor operated unit heaters.

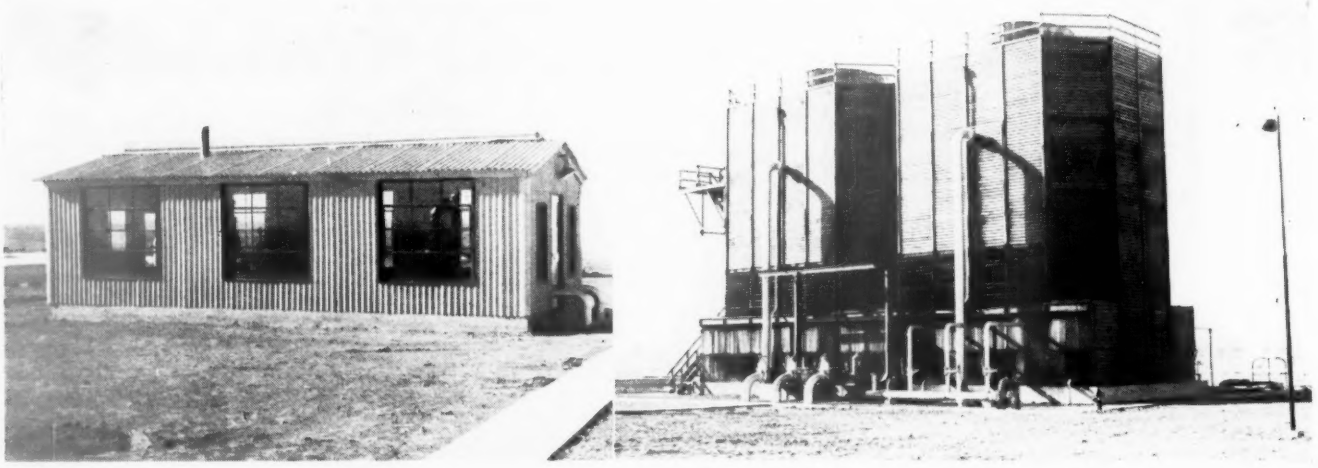
The compressor engines utilize the fuel gas at 25 psi and no individual engine regulators are used. The fuel gas header for the compressors is placed in the compressor room basement. The fuel gas for the generators and boiler is reduced from 25 to 1 psi in a dual setting of balanced pressure regulators. The utility gas to the plant offices, buildings,



Dehydration plant above shows inlet scrubber, contactor towers, and control house. All piping at unit is above ground. Dust scrubber installation below shows the two dust scrubbers, the structure holding the scrubber oil settling tanks and the equalizing tank. The scrubber oil storage tank is at the right.



Meter building has two 6-in. meter runs to handle all fuel gas. The building has exceptionally large windows. Two-cell cooling tower at right has spray water pumps, service hoist, and cold jacket water lines to atmospheric sections in tower.



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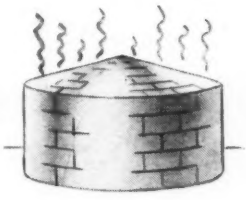

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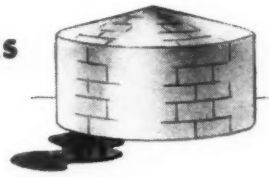
Seals at seams, eaves, around fittings.

BOTTOM LEAKS



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and to the camp is distributed at 25 psi pressure. The gas to the camp is odorized.

The emergency shutdown system provided is unusual in a compressor station. In this system, a high level float switch is installed in the inlet gas stop tank. High level in this tank serves to unload the pressure from the diaphragm of a motor valve in the fuel line to the compressors, closing this valve. Simultaneous with this a dump valve, controlled by the same level float valve, opens and releases all fuel gas to a stack remote from the plant. There are four emergency shutdown stations in the plant, one at the generator building, one at the compressor building, one at the inlet gas scrubbers, and one at the office. These stations function the same as the float valve.

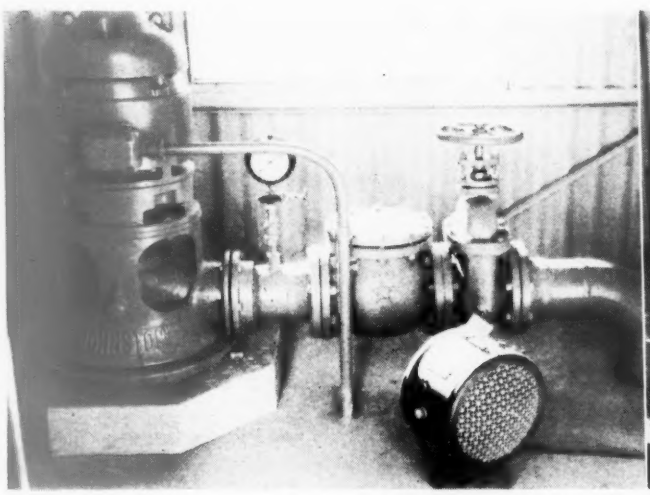
The dehydration plant fired heater and all controls at the dehydration plant use dehydrated gas.

● **Oil system.** A complete fresh oil supply and purifying system is provided. A 10-ft by 20-ft horizontal tank holds the supply of fresh oil. Two small positive displacement pumps take suction from this tank and discharge into a pressure tank in the generator building. This tank is provided with a pressure control switch to automatically start and stop the pumps, assuring a fresh oil supply under pressure at all times. Oil is supplied from this tank to dispenser sinks, one in the generator building and two in the compressor building. Fresh oil is metered through displacement meters at each dispenser allowing a constant check on the fresh oil consumed.

Two oil reclaimers are installed in the compressor building. Each has a capacity of 500 gal each 22 hr. One reclaimer operates with five compressor engines, and one reclaimer handles two compressors and the three generator engines. Positive control over the oil being reclaimed from each engine is possible through the use of interlinked three-way valves that are so arranged that the oil being reclaimed is returned to the engine being serviced.

Two dirty oil tanks are provided; one in each end of the compressor building to collect oil drained from an engine. A dirty oil pump handles drained oil from the generators to the dirty oil tanks. The oil reclaimers are arranged so that any oil in the dirty oil tanks may be purified and sent to reclaimed oil tanks, one in each end of compressor room. Reclaimed oil from these tanks is used entirely as makeup when available and they are piped to supply a second dispenser nozzle situated at the dispenser sinks. This oil is not metered. Oil is drained from the piston rod and packing gland drains to the dirty oil tanks where it is stored for future purification. Gas from the packing gland vents is piped to a trap at each compressor engine where the gas is released and the oil collected.

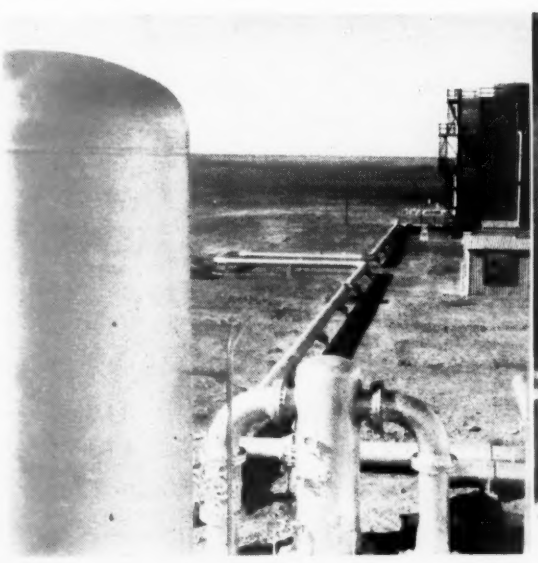
● **Dehydration plant.** The dehydration plant operates at the station discharge pressure and the piping is ar-



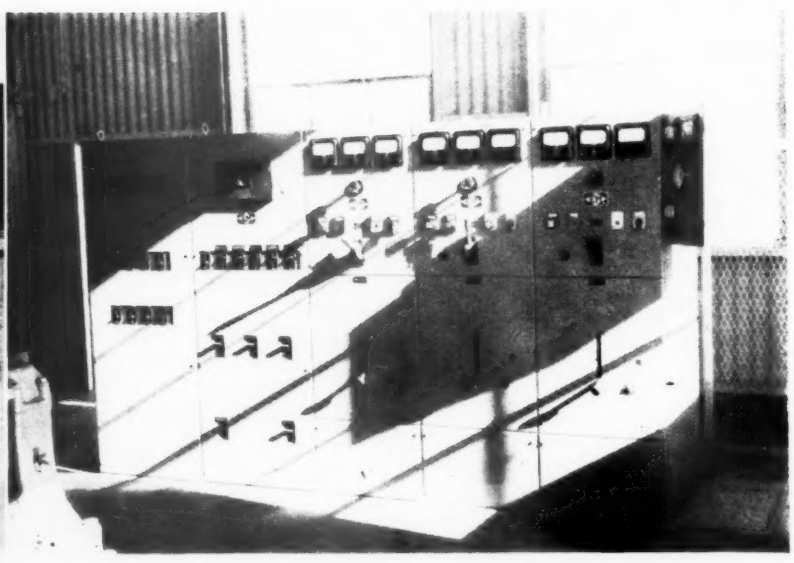
Water well pump installations are housed and portable electric heaters are used to heat equipment.

Heater for fuel gas installed in meter building and heated with hot jacket water is shown above.

Below is high pressure gas discharge line to cooling towers. High pressure gas lines are above ground.



Electric switchboard, pictured below, has three generator control panels and two feeder panels.



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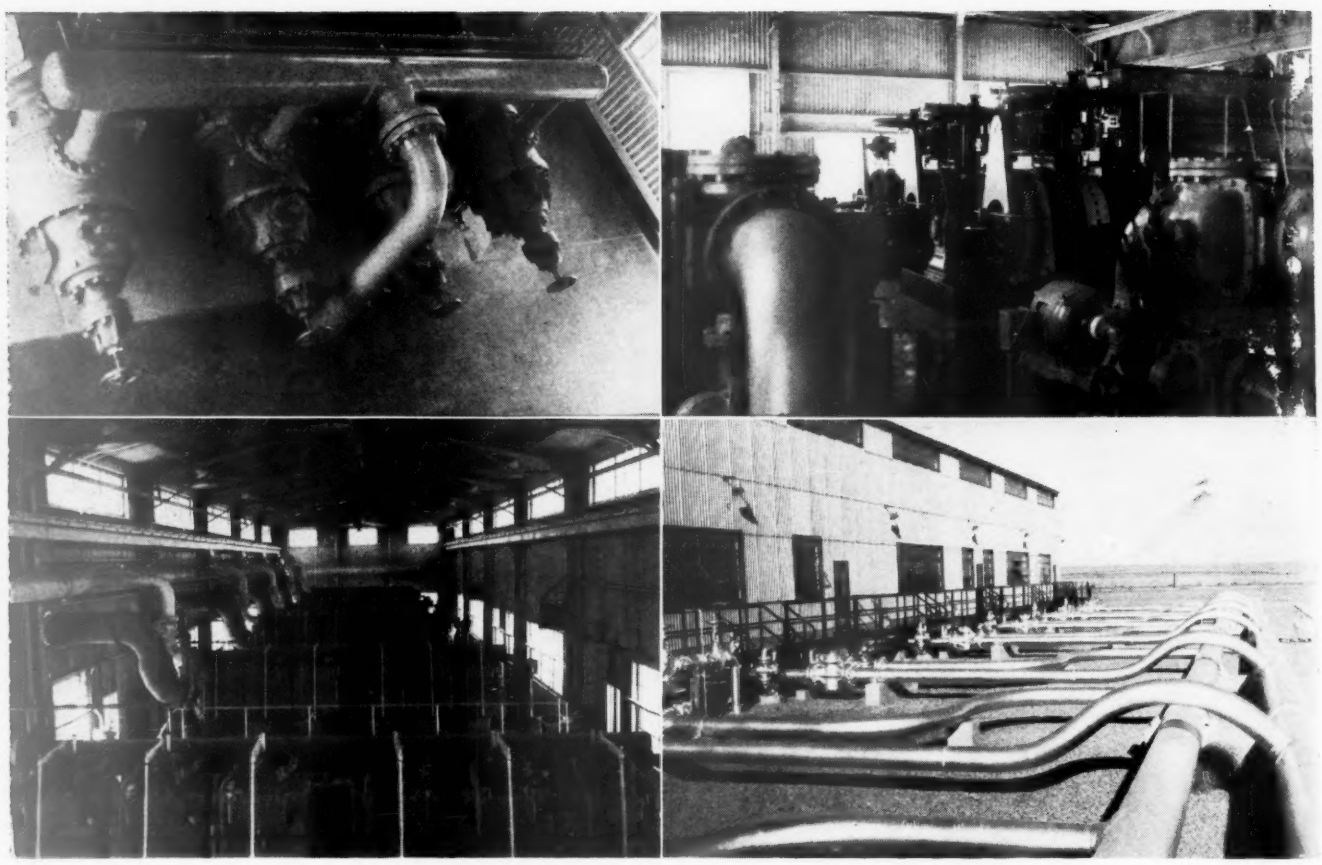


Top left, looking down on compressors shows large suction volume bottles installed immediately over the cylinders. Bottom left, interior view of compressor building. Top right, interior of generator building showing generators with top mounted exciters; cold jacket water pump in foreground. Bottom right, view of main suction and discharge headers and branch lines to compressors. Very light clamping is used as vibration has been largely designed out of the system.

ranged so that the entire dehydration system may be bypassed without interrupting the main flow of gas.

The plant is of the dry adsorbent type employing a granular desiccant. There are two towers used, 72 in. diam by 23 ft 6 in. net shell length. Each tower holds about 23,000 lb of desiccant and is designed to be operated 8 hr on stream with a flow of approximately 100,000,000 cu ft of gas a day at 900 psi and 80 F inlet gas temperature. Based upon such operation and flow of gas the plant produces a maximum dew point of 25 F.

A direct-fired heater is used to heat gas for regeneration of the tower not on stream. The flow of regenerated gas is from the heater to the tower being regenerated thence to two regeneration gas cooling coils placed in a bay of the cooling tower. These are atmospheric sections having two passes connected in series. The cooled gas then passes into the water separator, where the water is removed, and into the main gas stream to be sent on with the rest of the gas.

The required amount of regeneration gas is proportioned from the main gas stream to the contactors by use of a proportional flow controller.

A small steam-heated building houses the required flow and temperature control instruments and the water separator. Flow lines from the control instruments on the regeneration gas system are steam traced to prevent freezing. The direct-fired heater is protected from low flow or tube failure through the use of a device in the heater stack that automatically shuts down the fuel to the heater and cuts the pilot on excess temperature. Pilot flame failure is also protected by a fuel gas shutoff device that functions on pilot failure. In event the flow of fuel gas to the heater shuts off, the operating personnel are warned through a squawker horn. Arrangement of the plant is such that future contactors may be added to increase the capacity of the plant when desired.

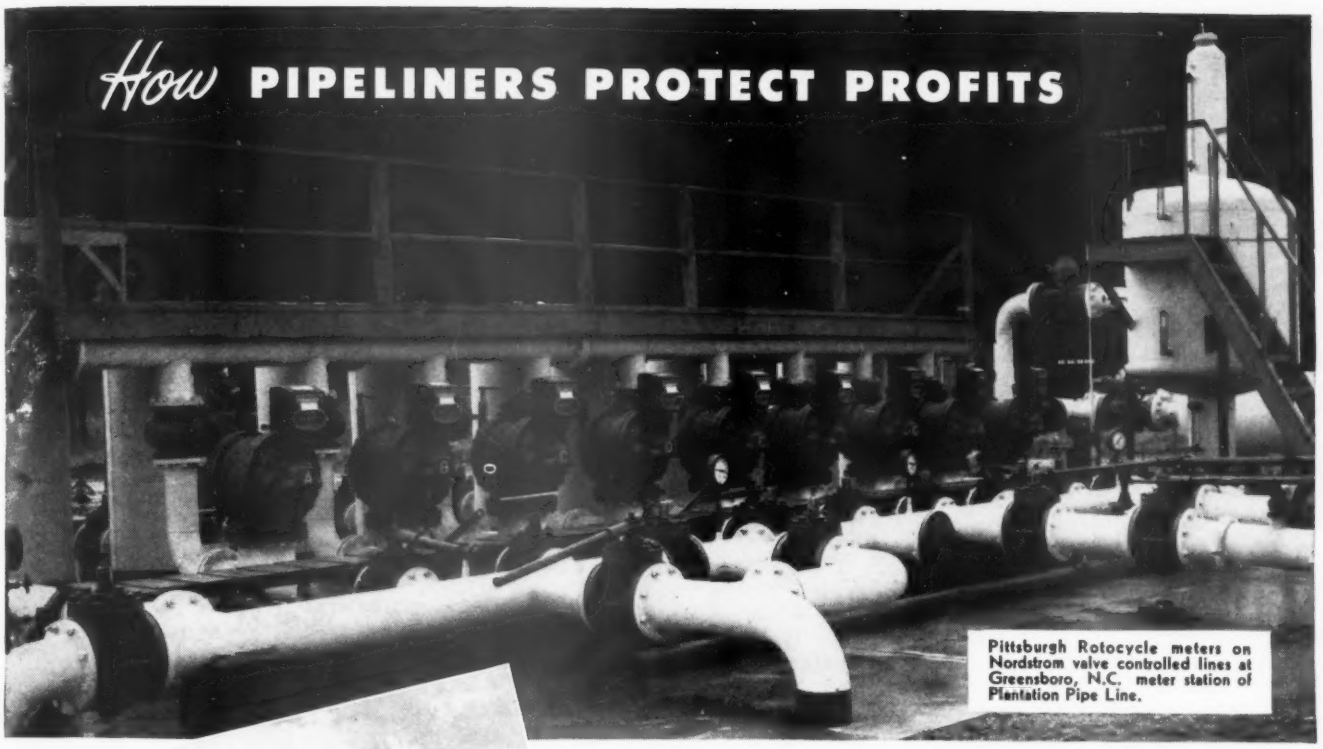
Dehydrated gas from the plant flows into the main pipe line. About one-fourth mile downstream from this plant a check metering station is situated. The gas is metered through three 12-in. meter runs each with its flow meter and with a single temperature recorder to serve all runs. Operating in parallel with the meter run flow meters are three additional differential flow meters that transmit flow records electrically to the dispatchers office at the plant giving an office record without the necessity of the operator visiting the metering station. These meters are also arranged so that the record of flow may be transmitted via telephone line to the company's main office in Colorado Springs, allowing the main dispatcher to check flows at all times.

● **Communications systems.** A complete telephone system has been installed between all major buildings in the station, the office and camp utilizing a switchboard in the office. A company telephone line also connects the station with the company dispatcher.

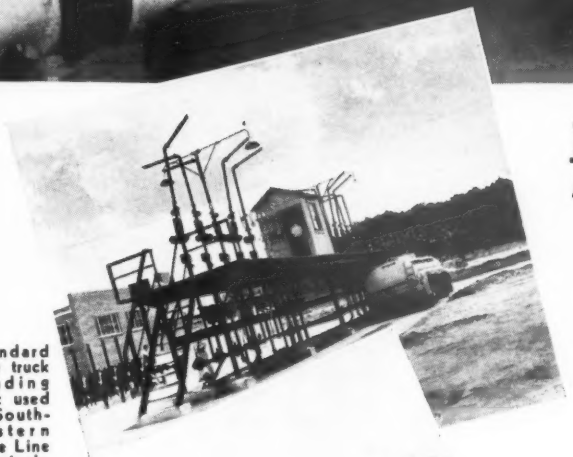
A frequency modulation radio system is set up with the station dispatcher as operator. The tower for this is situated on the station site and all company cars and trucks are radio equipped. This has been particularly valuable since the company is operating a large number of wells into the gathering systems. Future radio installations of the same type will allow communication with the company main office. At present, an aerial patrol is radio equipped to communicate with all cars and the station during the patrol of the pipe line.

● **Dust scrubbers.** Inlet gas lines to the station are 16 in. and 20 in. into a manifold piped into two dust scrubbers. Each scrubber has a capacity of 50,000,000 cu ft of gas at 220 psi pressure and is 48 in. in diameter by 19 ft high. These are so arranged that future scrubbers may be added easily. Each scrubber has large cleanout manholes in the base. The units are protected from over-

How PIPELINERS PROTECT PROFITS



Pittsburgh Rotocycle meters on Nordstrom valve controlled lines at Greensboro, N.C. meter station of Plantation Pipe Line.



Standard four truck loading rack used at Southeastern Pipe Line Terminals.

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A vast network of petroleum pipe lines now encompass the country. Rotocycle meters stand guard at input and dispersal points on a majority of the leading product pipe lines. They protect the profits. And they guide the handling of multiple products through the same line.

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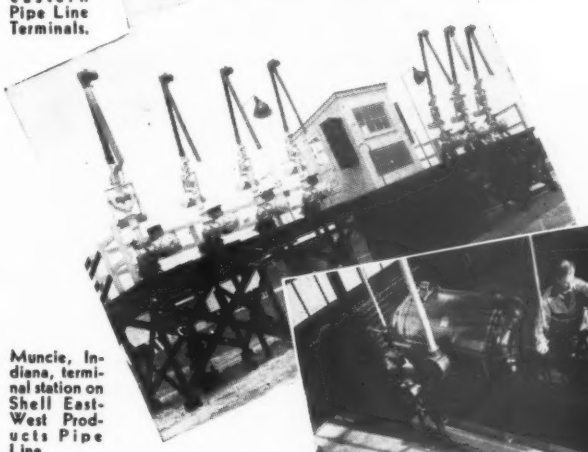
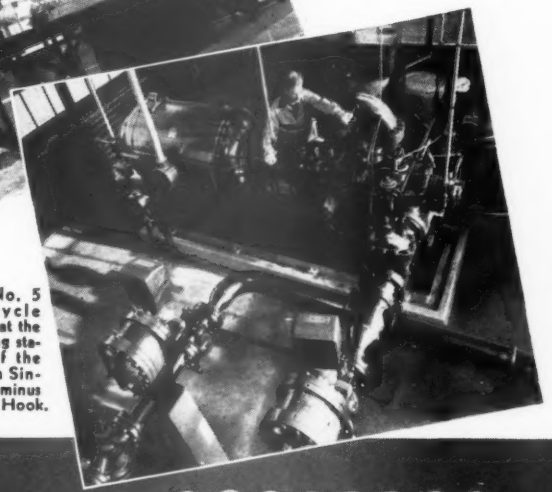


Muncie, Indiana, terminal station on Shell East-West Products Pipe Line.



Two No. 5 Rotocycle meters at the pumping station of the eastern Sinclair terminus Marcus Hook.

No. 6 Rotocycle meter with printing register.

PITTSBURGH ROTOCYCLE PIPE LINE METERS

pressure by means of a safety relief valve.

The dust scrubbers are of a general design that has proved quite effective in previous installations on major gas lines. The scrubbing efficiency is extremely high and the oil carryover is very small. These scrubbers have an automatic level control device that corrects for varying rates of flow without the services of an operator. This is a new feature and is used here for the first time.

A scrubber oil charging tank and two scrubber oil settling tanks are installed. The scrubber oil charging tank is built to the same design pressure as the scrubbers and after being filled with oil is equalized to the scrubber pressure, allowing the oil to gravitate into the oil reservoir in the scrubber. The scrubbers are blown into the settling tank where the oil entrained dust is allowed to settle out and the scrubber oil drawn off for re-use.

A 6 ft diam by 12 ft long horizontal storage tank has been installed for scrubber oil storage. Scrubber oil is moved from this tank to the scrubbers or charging tank by means of a positive displacement pump.

● **Piping design.** Standards of the American Standard Association Code for Pressure Piping were used in the design of the piping used in the station including the dehydration plant. Section 3 of this standard covering oil and gas piping inside refinery limits was used. Although the standard covering cross country pipe lines and compressor stations could have been used, the engineers responsible for the design have felt that this standard is not adequate for safe application to piping in such plants. Extensive experience in the design of compressor plants indicates that the more rigid requirements of Section 3 of the standard are more desirable because of the additional safety factor in piping, and is well justified on account of the concentrated risk to equipment and personnel. In this station, these standards were observed to points about 75 ft outside all plant boundaries.

● **Buildings.** The buildings for the station in general were custom-built for the installation. Specific exceptions are the pipe line warehouse and garage, which are standard 40-ft by 100-ft Quonset buildings and the office, which is a wooden frame asbestos-shingle covered structure.

The buildings, other than those indicated, are steel-frame covered with corrugated cement-asbestos board. All buildings have full ridge vents with dampers and the compressor building has a double row of windows. Windows in all cases are large and are set near the floor line to give exceptional light and ventilation.

The compressor and machine shop buildings are each provided with 4-ton bridge type cranes. The auxiliary building has a 2-ton crane of the same type, and the building is divided by partitions to provide a smoking room and change room for the station personnel.

The city of Bartlesville, Oklahoma, was given a deed to the first commercial well in the state by the owner, Cooperative Refining Association. The well was completed April 15, 1897.

☆ ☆ ☆

The auxiliary, office, and machine shop buildings have all required sanitary facilities. Electric drinking water fountains are also provided in all buildings. The station has a complete sewerage system including septic tanks and tile fields.

The main buildings are heated by low pressure steam supplied by a 15 psi gas-fired steam boiler installed in the auxiliary building. The steam is transmitted through underground steam mains to the buildings where it enters unit heaters; the condensate formed is returned to the boiler through a condensate return and makeup unit. The garage and machine shop are heated by direct gas-fired unit heaters.

The plant office is a 28-ft by 48-ft wooden frame building. The building is fully insulated and is covered with asbestos shingles. There are three offices provided, a laboratory room, a supply room, and a toilet room. A recording calorimeter has been installed in a specially walled off section of the laboratory room. The office has a forced air gas-fired furnace for heating and a ventilating fan to circulate air during the summer.

All buildings except the garage and pipe line warehouse are painted in colors that have been chosen for their psychological effect. The color harmonic scheme results in an overall effect that is at once pleasant and restful. The buildings lack any aspect of close confinement, such as is sometimes associated with interior arrangements involving considerable equipment.

● **Camp.** An extensive camp has been installed. Twenty houses and a large bunkhouse have been constructed. All camp buildings are custom-built and no prefabricated structures are used. The houses are all five rooms with full basements providing laundry, storage, and extra bedroom space. Two-car garages are provided—one to each two houses. The bunkhouse will handle 40 men and has complete recreation and dining facilities. The kitchen equipment is of the latest restaurant type and living quarters are provided for the steward.

Complete utilities including gas, water, lights, and sewerage are provided to all houses. A 20,000-gal double ellipsoidal and all-welded water storage tank 60 ft high provides adequate water under pressure for all domestic uses. Two 100-gpm pumps are installed in the auxiliary building to supply water to the elevated tank.

The compressor station and dehydration plant were designed and constructed by the Stearns-Roger Manufacturing Company in cooperation with the engineers of the Colorado Interstate Gas Company. The camp was constructed by the Abrahamson Construction Company. ★★★

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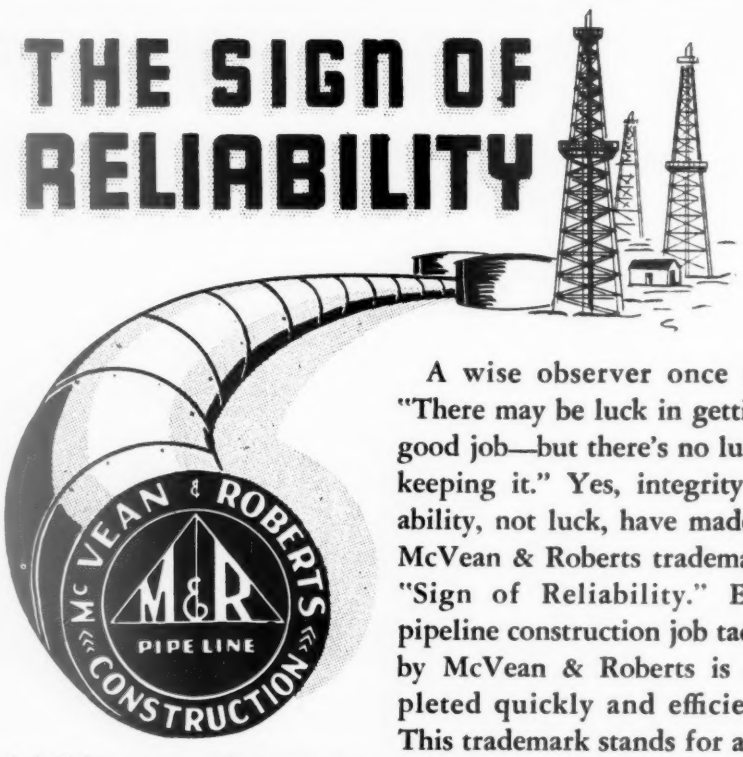

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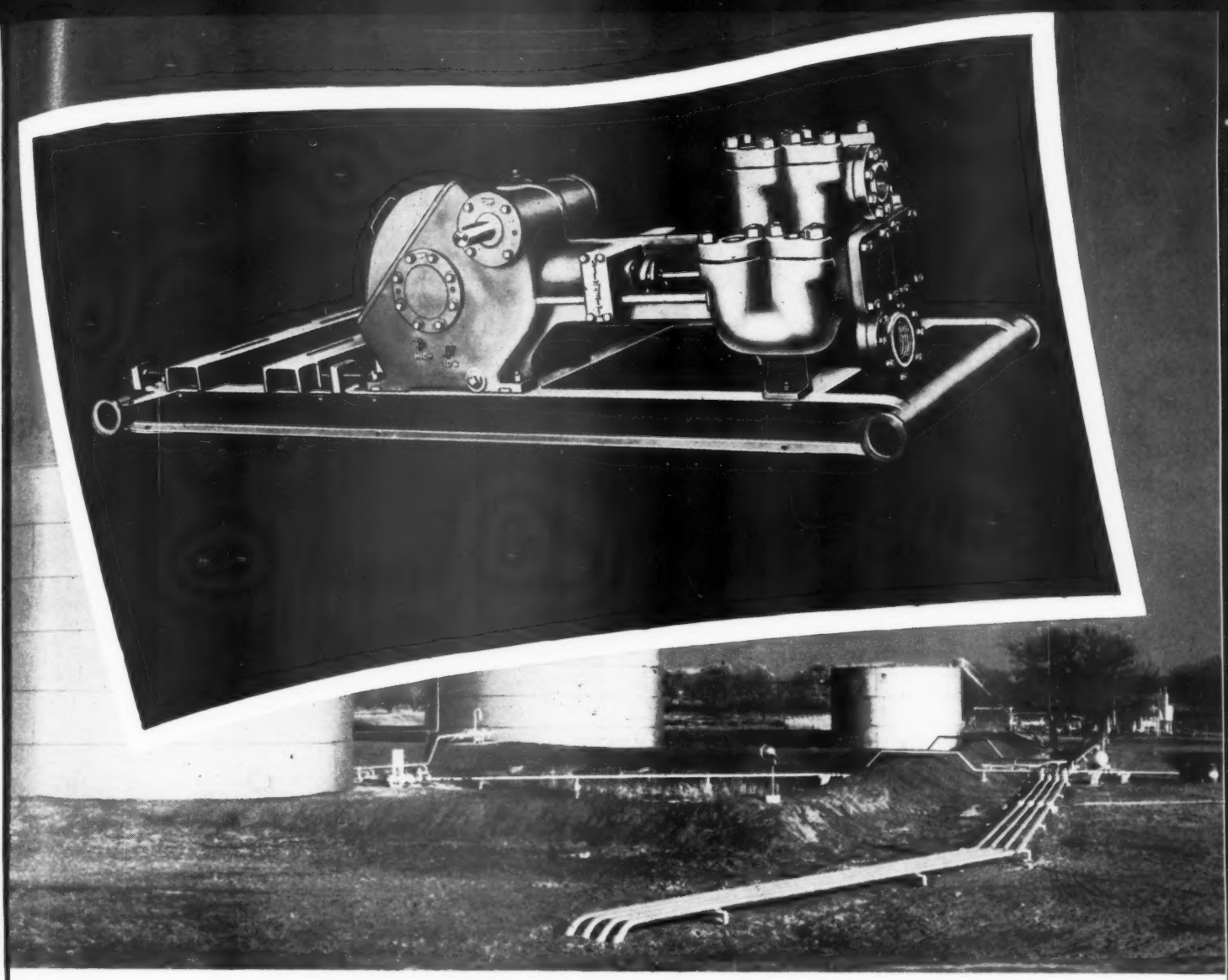

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Volume determination of tanks

By T. F. PHILLIANS, Engineer, Pipe Line Division, Shell Oil Company, Inc.

IN the petroleum industry extensive use is made of spherical, conical, horizontal, and vertical cylindrical tanks for processing and storage of hydrocarbon products. Oftentimes the cylindrical tanks have spherical and elliptical heads and the calculation of the quantity or volume of the contents in the preparation of gauge tables for these several different types of tanks has proved to be quite a problem for the engineer responsible for this work. In an effort to simplify the necessary calculations for such types of tanks, the formulas stated below were developed.

EXCLUSIVE

● **Spherical zone formula.** This is a general formula to obtain the volume of any part of a semisphere bounded by one or two intersecting horizontal planes, parallel to the plane passing through the center of the sphere. A typical application of this formula would be for spherical tanks such as the Hortonsphere or for vertical and horizontal cylindrical tanks with hemispherical heads.

● **Conical zone formula.** This is a general formula for calculating the volume of any part of a conical section in a vertical position bounded by one or two intersecting horizontal planes, parallel to a plane passing through the apex of the cone. An application of this formula would be for vertical cylindrical tanks with conical ends.

● **Elliptical zone formula.** For horizontal cylindrical tanks with elliptical ends, this is a general formula for determining the volume of any part of a spheroid bounded by one or two intersecting horizontal planes, parallel to a plane passing through the center perpendicular to the axis of revolution.

● **Elliptical zone formula.** For vertical cylindrical tanks with elliptical ends, a general formula for the volume of any part of a spheroid bounded by one or two intersecting horizontal planes, parallel to a plane passing through the center perpendicular to the axis of revolution.

These formulas are general in nature and in all cases the various radii and lengths of major and minor axes used should be the result of careful measurements made in the field. Generally speaking these measurements will conform very closely to the design measurements as shown on the manufacturer's drawings. In the following examples of application small measurements were used and consequently the calculations for the various constants were carried out to only four decimal places but for complete accuracy on large tanks the constants should be carried out to eight or ten places depending upon the calculating machine used. Also in the spherical zone formula on large tanks it may be found necessary to change the radius due to the construction of the tank and new constants will have to be calculated when this occurs.

The Author

T. F. Phillians, engineer in the Pipe Line Division for Shell Oil Company, Inc., in California, entered the service of the company in 1927 in the survey and drafting department. While in this department he was responsible for the strapping and calibration of all storage and process tanks for the refineries, production, and pipe line divisions. He also served as a member of the American Petroleum Institute Committee on Uniform Tank Measurements and Gauge Tables.

The general formulas were developed by the use of calculus and the derivation will not be given; however, in the computation of volumes in a series of increments such as this the general formula can be converted to such a form as to allow use of arithmetic progression of the upper and lower limits of this increment, permitting the series of volumes to be easily computed by use of a calculating machine. Following are examples of the four general formulae:

Spherical zone formula:

$$V_1 = \pi GF\left(R^2 - \frac{G^2}{3} - AB\right) \quad . \quad . \quad (1)$$

In which:

V_1 = the volume of the spherical segment between limits A and B.
A = the radial distance from the center of the sphere to the closer intersecting horizontal plane.
B = the radial distance from the center of the sphere to the more distant intersecting horizontal plane.
R = the radius of the sphere.
G = the distance between the limits A and B.
F = the volume factor (as 7.4805, the number of U. S. gal. per cu ft).

In the preparation of gauge tables for tanks, it is necessary to obtain the volumes for small increments such as 1, ½, or ¼ in., in which case the factor G in formula (1) would become 1, ½, or ¼ in. expressed in the common unit. Formula (1) can be further simplified so that the volumes of a series of increments can be obtained very readily by the use of a calculating machine.

Thus, the volume of any small section, M sections from the center of the sphere, becomes:

$$V_M = \pi GF\left(R^2 - \frac{G^2}{3} - AB\right)$$

$$= \pi GF\left[R^2 - \frac{G^2}{3} - (M-1)\,G \times MG\right]$$

Where $(M-1)G$ is substituted for A and MG is substituted for B, M being the number of sections (of depth G) from the center of the sphere. Simplifying:

$$V_M = \pi GF\left[R^2 - \frac{G^2}{3} - (M^2 - M)G^2\right]$$

Let:

$$K_1 = \pi GFR^2 - \frac{\pi G^3F} \quad . \quad . \quad . \quad (2)$$

$$K_2 = 2\pi G^3F \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Then:

$$V_M = K_1 - \frac{M^2 - M}{2} K_2 \quad . \quad . \quad (4)$$

The volume of the $(M+1)^{th}$ section will be:

$$V_{M+1} = K_1 - \frac{(M+1)^2 - (M+1)}{2} K_2$$

$$= K_1 - \frac{M^2 + M}{2} K_2$$

$$V_M - V_{M+1} = K_1 - \frac{M^2 - M}{2} K_2 - K_1 + \frac{M^2 + M}{2} K_2 = MK_2$$

From which:

$$V_M = V_{M+1} + MK_2 \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Formulae (4) and (5) offer a very simple means of computing the volumes of a series of increments or sections of a semisphere. By using formula (4) to obtain the volume of any particular section M, then formula (5) can be set up in a calculating machine so that the vol-

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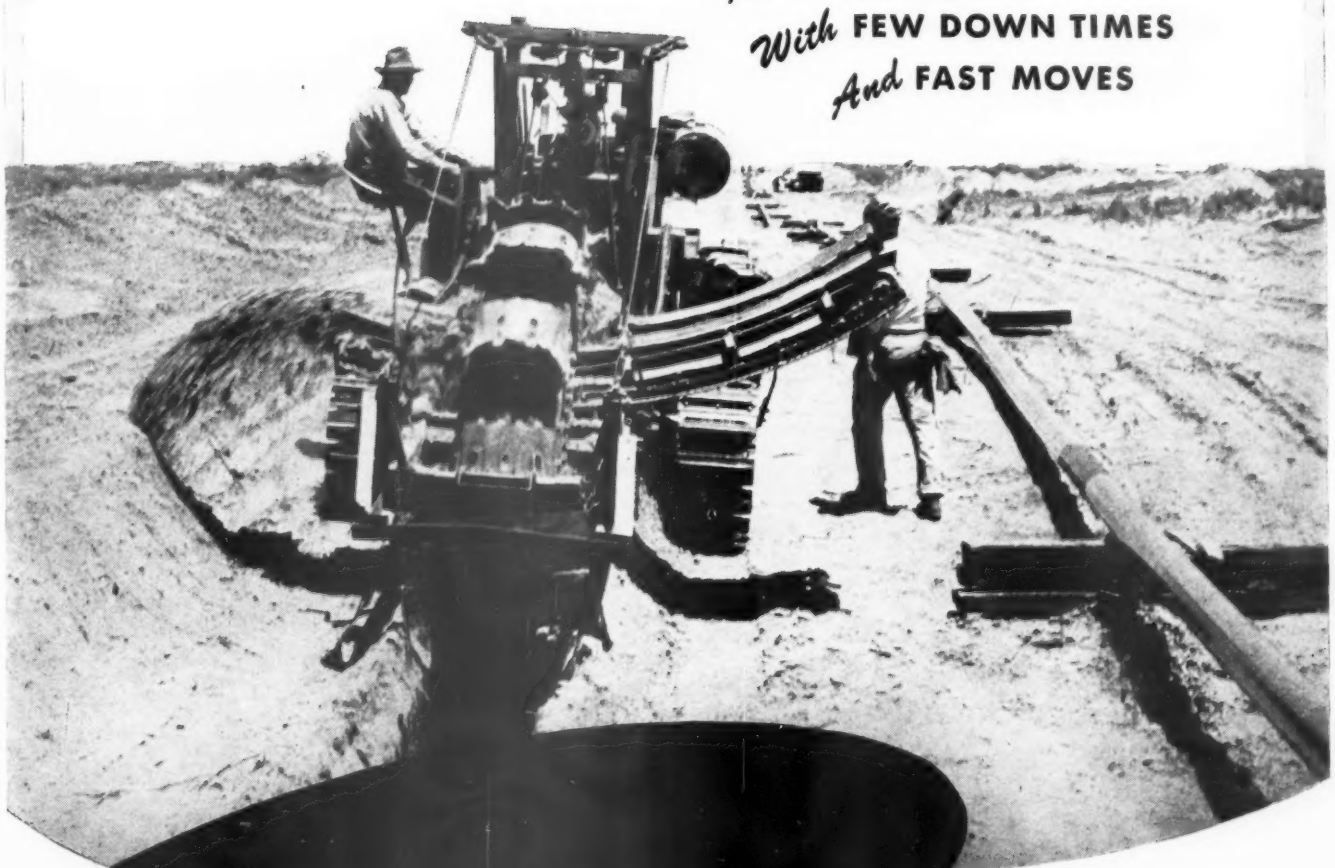

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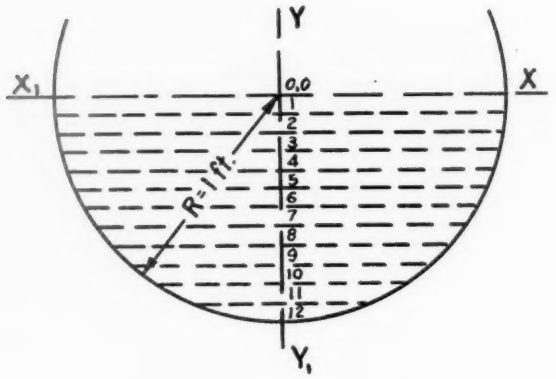

FIG. 1.

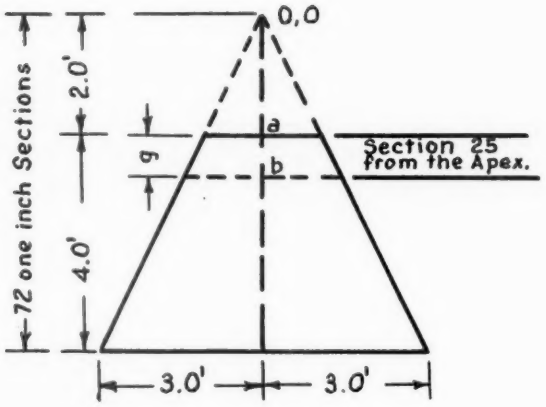

FIG. 2.

umes of a series of sections approaching the center of the sphere can easily be computed.

For example in Fig. 1, if:

R = 1.0 ft

G = 1 in. = 0.083333 ft

F = 7.4805 gal per cu ft.

Find the individual and cumulative volumes of the twelve 1-in. sections.

Solution:

Using formula (2): $K_1 = 1.9539$

Using formula (3): $K_2 = 0.027200$.

Substituting in formula (4), the volume of the 12th section from the center of the sphere is:

$$V_{12} = 1.9539 - \frac{12^2 - 12}{2} \times 0.0272$$

$$= 0.159 \text{ gal.}$$

Then substituting in formula (5), the volume of the 11th section is:

$$V_{11} = V_{12} + 11\,K_2$$

$$= 0.159 + 11 \times 0.027200$$

In the application of formula (5) to a calculating machine, the value of V_{12} is placed in the lower dial, and K_2 is placed in the keyboard, making sure that the decimal point is placed correctly. Then multiply by each decreasing value of M, as 11, 10, 9, etc., for the volume of each particular section M. During the series of calculations, the lower dial and the keyboard are not cleared at any time.

The complete set of calculations for the twelve 1-in. sections is as follows:

Section number	Volume of section, gal	Cumulative volumes, gal
12	0.159	0.159
11	0.458	0.617
10	0.730	1.347
9	0.975	2.322
8	1.193	3.515
7	1.383	4.898
6	1.546	6.444
5	1.682	8.126
4	1.791	9.917
3	1.873	11.790
2	1.927	13.717
1	1.954	15.671

As a check for the total volume, formula (1) is applicable:

$$\text{Volume} = \pi GF\left(R^2 - \frac{G^2}{3} - AB\right)$$

In this case:

A = 0 and B = R

R = 1 ft.

G = 1 ft.

F = 7.4805 gal per cu ft.

Therefore:

Volume = 15.667 gal.

Conical zone formula:

$$V_1 = \frac{\pi F}{3N^2}(3GAB + G^3) \quad . \quad . \quad . \quad (6)$$

In which:

V_1 = the volume of the conical segment between limits A and B,

A = the distance from the apex of the cone to the closer intersecting horizontal plane,

B = the distance from the apex of the zone to the more distant intersecting horizontal plane,

N = the slope of the cone (the height of the cone divided by the radius of the base),

G = the distance between the limits A and B,

F = the volume factor (as 7.4805, the number of U. S. gal per cu ft).

Thus, the volume of any small section M from the apex of the cone becomes:

$$V_M = \frac{\pi F}{N^2}(GAB) + \frac{\pi FG^3}{3N^2}$$

$$= \frac{\pi F}{N^2}\left[G \times (M-1)G \times (MG)\right] + \frac{\pi FG^3}{3N^2}$$

When (M—1) G is substituted for A and (MG) is substituted for B, M being taken as the number of G sections from the apex of the cone:

$$V_M = \frac{2\pi FG^3}{N^2}\left(\frac{M^2 - M}{2}\right) + \frac{\pi FG^3}{3N^2}$$

$$K_3 = \frac{2\pi FG^3}{N^2} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Then:

$$V_M = K_3\frac{(M^2 - M)}{2} + \frac{K_3}{6} \quad . \quad . \quad (8)$$

The volume of the $(M+1)^{th}$ section will be:

$$V_{M+1} = K_3\frac{(M+1)^2 - (M+1)}{2} + \frac{K_3}{6}$$

$$= K_3\frac{M^2 + M}{2} + \frac{K_3}{6}$$

$$V_{M+1} - V_M = K_3\left(\frac{M^2 + M}{2}\right) + \frac{K_3}{6} - K_3\left(\frac{M^2 - M}{2}\right) + \frac{K_3}{6} = MK_3$$

From which:

$$V_{M+1} = V_M + MK_3 \quad . \quad . \quad . \quad . \quad . \quad (9)$$

The application of formulas (8) and (9) is similar to that of formulas (4) and (5).

For example, in Fig. 2, if:

G = 1 in. = 0.083333 ft,

N = 2

F = 7.4805 gal per cu ft.

Find the individual and cumulative volumes of the 48 1-in. sections from 2 to 6 ft below the apex.

Solution: From formula (7):

$K_3 = 0.0068$.

Substituting in formula (8), the volume of the 25th section from the apex is:

$$V_{25} = 0.0068 \times \frac{25^2 - 25}{2} + 0.001$$

$$= 2.041 \text{ gal.}$$

Then substituting in formula (9), the volume of section 26 is:

$$V_{26} = V_{25} + 25\,K_3$$

$$= 2.041 + 25 \times 0.0068$$

$$= 2.211 \text{ gal.}$$

In applying formula (9) to a calculating machine, the value V_{25} is placed in the lower dial and K_3 is placed on the keyboard. Then multiply by each increasing value of M, as 25, 26, 27, etc., for the necessary volumes.

The complete set of calculations for the 48 1-in. sections is as follows:

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Section number	Volume of section, gal	Cumulative volumes, gal
25	2.041	2.041
26	2.211	4.252
27	2.388	6.640
28	2.572	9.212
29	2.762	11.974
30	2.959	14.933
31	3.163	18.096
32	3.374	21.470
33	3.592	25.062
34	3.816	28.878
35	4.047	32.925
36	4.285	37.210
37	4.530	41.740
38	4.782	46.522
39	5.040	51.562
40	5.305	56.867
41	5.577	62.444
42	5.856	68.300
43	6.142	74.442
44	6.434	80.876
45	6.733	87.609
46	7.039	94.648
47	7.352	102.000
48	7.672	109.672
49	7.998	117.670
50	8.331	126.001
51	8.671	134.672
52	9.018	143.690
53	9.372	153.062
54	9.732	162.794
55	10.099	172.893
56	10.473	183.366
57	10.854	194.220
58	11.242	205.462
59	11.636	217.098
60	12.037	229.135
61	12.445	241.580
62	12.860	254.440
63	13.282	267.722
64	13.710	281.432
65	14.145	295.577
66	14.587	310.164
67	15.036	325.200
68	15.492	340.692
69	15.954	356.646
70	16.423	373.069
71	16.899	389.968
72	17.382	407.350

As a check for the total volume using formula (6):

$$\text{Volume} = \frac{\pi F}{3N^2}(3\,GAB+G^3)$$

Where:

A=2.0 ft

B=6.0 ft

G=4.0 ft.

Volume=407.347 gal.

Elliptical zone formula for horizontal cylindrical tanks:

$$V_1 = \frac{\pi BGF}{6A}(3A^2-3CD-G^2) \quad \ldots\ldots\ldots\ldots (10)$$

In which:

V_1 = the volume of the segment between limits C and D,

C = the distance from the center of the spheroid to the closer intersecting horizontal plane,

D = the distance from the center of the spheroid to the more distant intersecting horizontal plane,

A = one-half the major axis,

B = one-half the minor axis,

G = the distance between the limits C and D,

F = volume factor (as 7.4805, the number of U. S. gal per cu ft).

Thus, the volume of any small section M from the center of the spheroid becomes:

$$V_M = \frac{\pi BFG}{2A}(A^2-CD) - \frac{\pi BG^3F}{6A}$$

$$= \frac{\pi BFG}{2A}\left[A^2-(M-1)G\times(MG)\right] - \frac{\pi BG^3F}{6A}$$

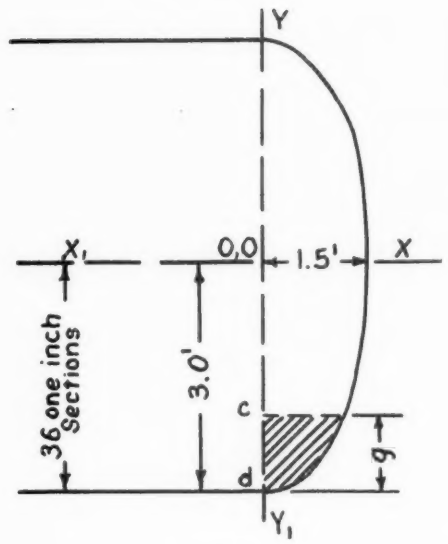

FIG. 3.

Where (M—1)G is substituted for C and (MG) is substituted for D, M being taken as the number of G sections from the center of the spheroid.

$$V_M = \frac{\pi BFG}{2A}\left[A^2-(M^2-M)G^2\right] - \frac{\pi BG^3F}{6A}$$

Let:

$$K_4 = \frac{\pi BGFA}{2} - \frac{\pi BG^3F}{6A} \quad \ldots\ldots (11)$$

$$K_5 = \frac{\pi BG^3F}{A} \quad \ldots\ldots (12)$$

Then:

$$V_M = K_4 - \frac{M^2-M}{2}K_5 \quad \ldots\ldots (13)$$

The volume of the $(M+1)^{th}$ section will be:

$$V_{M+1} = K_4 - \frac{(M+1)^2-(M+1)}{2}K_5$$

$$= K_4 - \frac{M^2+M}{2}K_5$$

$$V_M - V_{M+1} = K_4 - \frac{M^2-M}{2}K_5 - K_4 + \frac{M^2+M}{2}K_5$$

$$= MK_5$$

Therefore:

$$V_M = V_{M+1} + MK_5 \quad \ldots\ldots (14)$$

The application of formulas (13) and (14) is similar to (4) and (5) as given in the spherical zone formulas.

For example, in Fig. 3, if:

A=3.0 ft

B=1.5 ft

G=1 in.=0.083333 ft

F=7.4805 gal per cu ft.

Find the individual and cumulative volumes of the 36 1-in. sections.

Solution:

From formula (11): K_4=4.4053.

From formula (12): K_5=0.0068.

Substituting in formula (13), the volume of the 36th section from the center of the spheroid is:

$$V_{36} = 4.4053 - \frac{36^2-36}{2}K_5$$

$$= 0.121 \text{ gal.}$$

Then substituting in formula (14), the volume of the 35th section is:

$$V_{35} = V_{36} + 35\,K_5$$

$$= 0.121 + 35\times 0.0068.$$

In the application of formula (14) to the calculating machine, the value V_{36} is placed in the lower dial and K_5 is placed on the keyboard. Then multiply by each decreasing value of M, as 35, 34, 33, etc., for the volume of that particular section M. The complete set of calculations for the 36 1-in. sections is as follows:

Section number	Volume of section, gal	Cumulative volumes, gal
36	0.121	0.121
35	0.359	0.480
34	0.590	1.070
33	0.815	1.885
32	1.032	2.917
31	1.243	4.160
30	1.447	5.607
29	1.644	7.251
28	1.835	9.086
27	2.018	11.104
26	2.195	13.299
25	2.365	15.664
24	2.528	18.192
23	2.685	20.877
22	2.834	23.711
21	2.977	26.688
20	3.113	29.801
19	3.242	33.043
18	3.365	36.408
17	3.480	39.888
16	3.589	43.477
15	3.691	47.168
14	3.786	50.954
13	3.875	54.829
12	3.956	58.785
11	4.031	62.816
10	4.099	66.915
9	4.160	71.075
8	4.215	75.290
7	4.262	79.552
6	4.303	83.855
5	4.337	88.192
4	4.364	92.556
3	4.385	96.941
2	4.398	101.339
1	4.405	105.744

Using formula (10) to check the total volume:

$$\text{Volume} = \frac{\pi BGF}{6A}(3A^2-3CD-G^2)$$

Where:

C=0

D=3.0 ft

G=3.0 ft.

Volume=105.753 gal.

Elliptical zone formula for vertical tanks:

$$V_1 = \frac{\pi A^2GF}{3B^2}(3B^2-3CD-G^2) \quad \ldots\ldots\ldots\ldots (15)$$

In which:

V_1 = the volume of the segment,

C = the distance from the center of the spheroid to the closer bounding plane,

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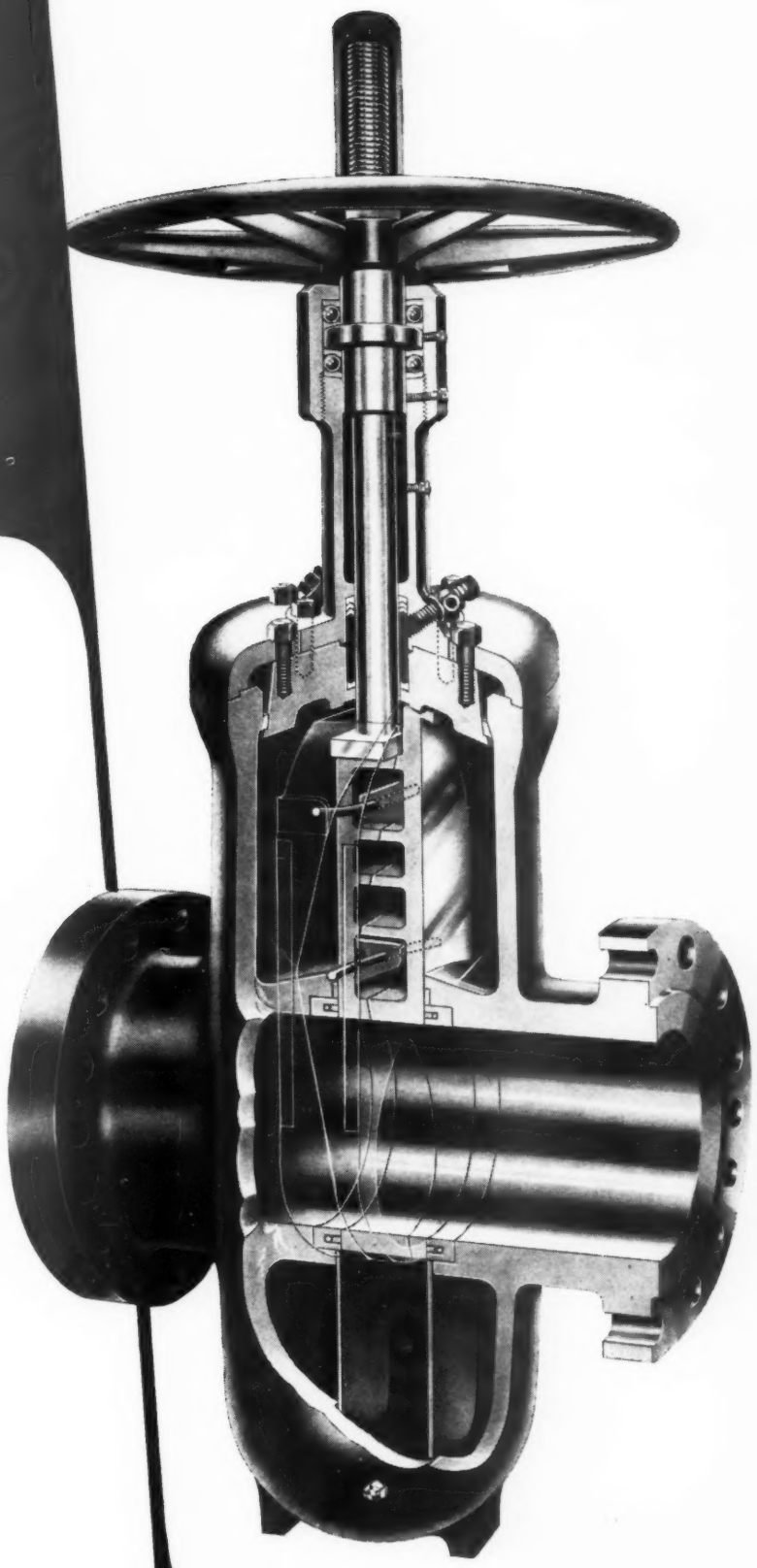

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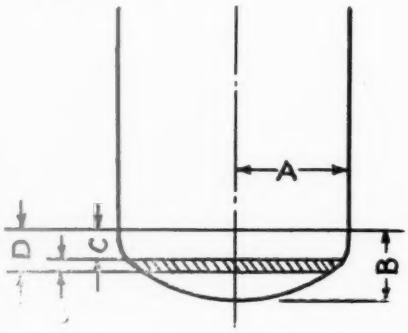

FIG. 4.

D = the distance from the center of the spheroid to the more distant bounding plane,

A = one-half of the major axis,

B = one-half of the minor axis,

G = D — C

F = volume factor (as 7.4805, the number of U. S. gal. per cu ft).

Then, if the semispheroid be divided into a uumber of segments of equal height G, the volume of the M^{th} segment from the center of the spheroid is:

$$V_M = \frac{\pi A^2GF}{B^2}\left[B^2 - \frac{G^2}{3} - (M-1)\,G\,(MG)\right]$$

Where:

(M—1) G=C

And:

MG=D

Therefore:

$$V_M = \frac{\pi A^2GF}{B^2}\left[B^2 - \frac{G^2}{3} - (M^2-M)G^2\right]$$

$$V_M = \left(\pi A^2GF - \frac{\pi A^2G^3F}{3B^2}\right) - \left(\frac{2\pi A^2G^3F}{B^2}\right)\left(\frac{M^2-M}{2}\right)$$

Let:

$$K_6 = \pi A^2GF - \frac{\pi A^2G^3F}{3B^2} \quad . \quad . \quad (16)$$

$$K_7 = \frac{2\pi A^2G^3F}{B^2} \quad . \quad . \quad . \quad . \quad (17)$$

Then:

$$V_M = K_6 - \left(\frac{M^2-M}{2}\right)K_7 \quad . \quad . \quad (18)$$

The volume of the $(M+1)^{th}$ segment will be:

$$V_{M+1} = K_6 - \frac{(M+1)^2-(M+1)}{2}K_7$$

$$= K_6 - \left(\frac{M^2+M}{2}\right)K_7$$

Then:

$$V_M - V_{M+1} = K_6 - \left(\frac{M^2-M}{2}\right)K_7 - K_6 + \left(\frac{M^2+M}{2}\right)K_7 = MK_7$$

Whence:

$$V_M = V_{M+1} + MK_7 \quad . \quad . \quad . \quad . \quad . \quad (19)$$

That is, the volume of any segment of the spheroid is equal to the sum of the volume of the succeeding segment and the product of the number of the segment and the constant K_7.

In applying the formula to a tank, the volume of the final segment is found by using formula (18); then the volume of each preceding segment is found by the use of formula (19). In using a calculating machine, the volume of the final segment is placed in the lower dial and K_7 is placed on the keyboard. Then each decreasing value of M is used as a multiplier of K_7 and is added to the volume found previously; that is, the lower dial is not cleared during the process.

Following is an example showing the application of formulae (15), (18), and (19):

In Fig. 5 if:

A = 3.0 ft

B = 1.5 ft = 18 in.

G = 1 in. = 0.083333 ft

F = 7.4805 gal per cu ft.

Find the individual and cumulative volumes of the 18 1-in. sections.

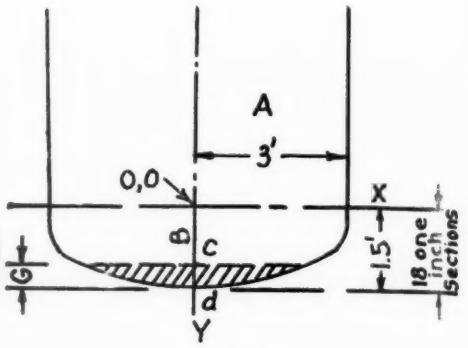

FIG. 5.

Solution:

From formula (16) $K_6 = 17.6074$.

From formula (17) $K_7 = 0.1088$.

Substituting in formula (18) the volume of the 18th section from the center of the spheroid is:

$$V_{18} = 17.6074 - \frac{18^2-18}{2} \times 0.1088$$

$$= 0.9610 \text{ gal.}$$

Then substituting in formula (19) the volume of the 17th section is:

$$V_{17} = V_{18} + 17K_7$$

$$= 0.9612 + 17 \times 0.1088$$

$$= 2.8106 \text{ gal.}$$

In the application of formula (19) to the calculating machine, the value V_{18} is placed in the lower dial and K_7 is placed on the keyboard. Then multiply by each decreasing value of M, as 17, 16, 15, etc., for the volume of that particular section M. During the series of calculations, the lower dial and the keyboard are not cleared at any time.

The complete set of calculations for the 18 1-in. sections is as follows:

Section number	Volume of section, gal	Cumulative volumes, gal
18	0.9610	0.9610
17	2.8106	3.7716
16	4.5514	8.3230
15	6.1834	14.5064
14	7.7066	22.2130
13	9.1210	31.3340
12	10.4266	41.7606
11	11.6234	53.3840
10	12.7114	66.0954
9	13.6906	79.7860
8	14.5610	94.3470
7	15.3226	109.6696
6	15.9754	125.6450
5	16.5194	142.1644
4	16.9546	159.1190
3	17.2810	176.4000
2	17.4986	193.8986
1	17.6074	211.5060

Using formula (15) to check the total volume:

$$\text{Volume} = \frac{\pi A^2GF}{3B^2}(3B^2 - 3CD - G^2)$$

Where:

C = 0

D = 1.5 ft = B

G = 1.5 ft = B

$$\text{Volume} = \frac{2}{3}\pi A^2BF = 211.5066 \text{ gal.}$$

★ ★ ★

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(Photo courtesy H. C. Price Company)

Stringing coated pipe along the right-of-way. The pipe is placed on sand bags to protect coating from rocks and rough terrain.

Borger-Denver products pipe line

By FRANK H. LOVE, *Managing Editor*

EXCLUSIVE

THE Borger-Denver products line, in which Phillips Petroleum Company and Shamrock Oil and Gas Corporation are jointly interested, has been partially completed and the first section, from Borger to La Junta, placed in operation. The section from the latter point to Denver will be laid as soon as the line pipe is available. The overall project involves laying 365 miles of 6-in. pipe and construction of three pumping stations and two terminals.

Already in operation are 37 miles of pipe line from Borger to McKee station, in Moore County, and the Rocky Station near Borger, which are wholly owned by Phillips; McKee station, 165 miles of line from that station to La Junta, Colorado, and a terminal at the latter point, which are owned jointly by Phillips and Shamrock. Yet to be constructed are 154 miles of line from La Junta to Denver, a pumping station at La Junta, and a terminal at Denver. These will be wholly owned by Phillips, which company will also operate the entire system.

Under this setup maximum line capacity will be 9000 bbl a day. An increase of 14,400 bbl a day is contemplated for a later date, which will necessitate the installation of two additional stations, one between McKee and La Junta and the other between La Junta and Denver.

Phillips products will be transported from Borger to La Junta and Denver, and Shamrock products from McKee to La Junta. The products handled are the various grades of motor fuel and aviation gasoline, kerosine, diesel fuel, distillate, butane, and propane. All products passing through the line are metered at McKee station and all products drawn off are metered at La Junta and will be metered at the Denver terminal. Positive displacement meters are used for metering.

● **Line construction.** The line follows almost a direct line from Borger to McKee and McKee to Denver; however, elevation along the route varies considerably. At Borger the elevation is 2940 ft, at McKee 3550 ft, at La Junta 4075 ft, and at Denver 5200 ft. There is a high point south of La Junta of 5043 ft and the highest elevation attained is 6650 ft, at a point south of Denver. In addition to the wide variation in elevations, part of the right-of-way is through extremely rocky terrain. These factors necessitated detailed planning and engineering skill.

To determine the right-of-way and alignment, officials first flew over the route to obtain a general idea of the terrain and as much additional information as possible, locating heavy rock outcrops, canyons, etc. At the same time

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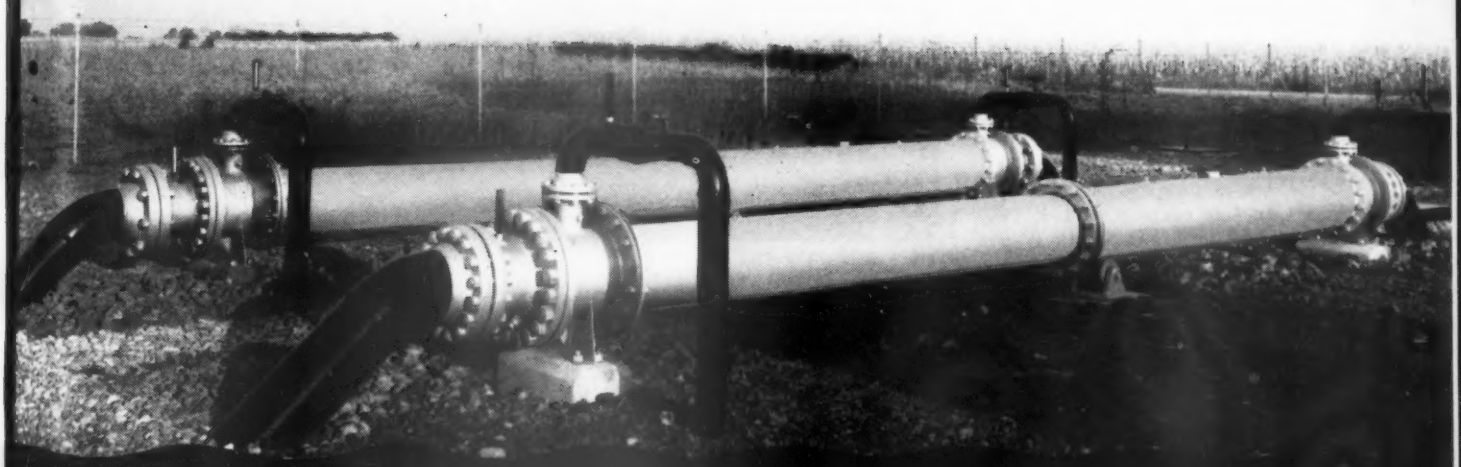

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control points on alignment were determined. Then aerial photographs were made of the right-of-way, and the same firm that performed the photography supplied ownerships along the route of the line. From these aerial photographs right-of-way maps were constructed, and, using them, the Right-of-Way Department was able to purchase the entire right-of-way for the line before a single stake was set in the ground. After the right-of-way was purchased, the line was staked and a continuous profile run. Finally, a re-survey was made over the completed line and this basic information was utilized to assign mileposts, determine location of main line valves and fittings, show distances along the line, compute volume of products that could be pumped, and, in fact, identify everything on the system. Additionally, the profile map is of inestimable value in making hydraulic calculations and in determining the amount of products that would be lost in event of a line leak.

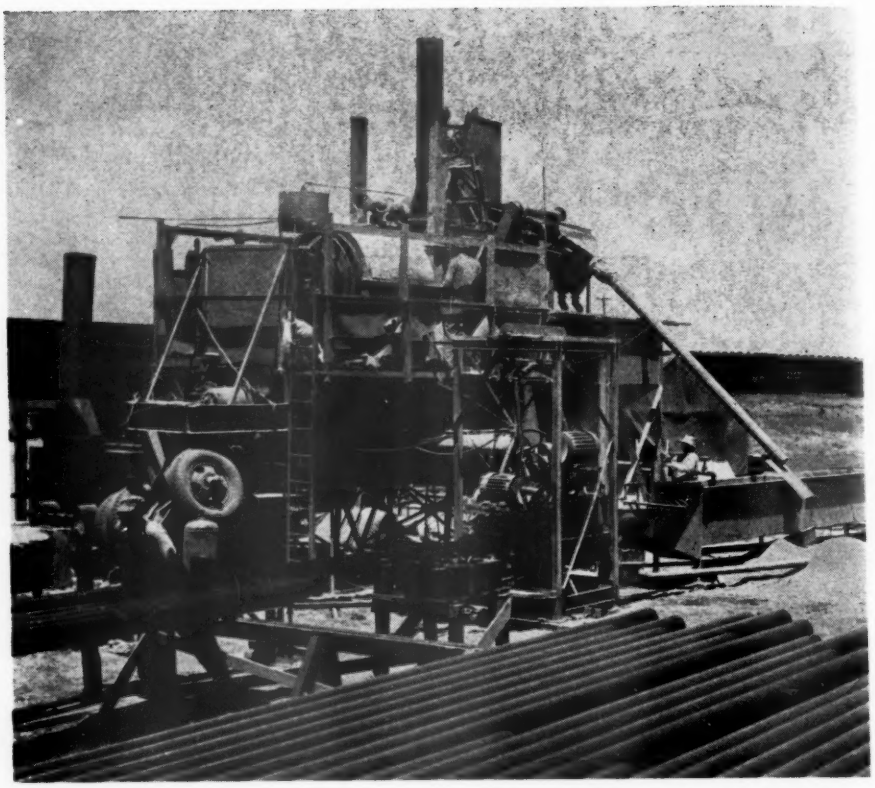
For the main line 6⅝-in. OD, 3/16-in. wall thickness electric resistance welded pipe is used. The pipe has an effective yield strength of 40,000 psi. All main line valves are full opening 6¼ in. ID for the passage of scrapers if necessary. The maximum line pressure of 1510 psi is determined by the strength of the pipe.

The principal difficulty, insofar as the laying of the pipe was concerned, was caused by the rocky terrain that extended intermittently from south of the Cimarron River into La Junta. In this area it was necessary to blast and remove the rock from the pipe line trench with backhoes. In crossing dry creeks, deep gulleys, and small creeks, the usual practice was to support the pipe on A-frames.

Four rivers were crossed between Borger and La Junta: South Canadian, North Canadian, Cimarron, and Purgatorie. The pipe at all crossings except the Cimarron was buried 2 ft below the river bed. The Cimarron crossing was buried 14 to 15 ft below the river bed and this required sandpointing to remove the water while the trench was made and the pipe lowered. River clamps weighing 430 lb each were used on all crossings. The total length of the North Canadian crossing was 675 ft, the actual width of the river bed 375 ft, and 475 ft of pipe were laid at a depth of 2 ft below the river bed. The Cimarron crossing totaled 2370 ft, the river bed 600 ft, and 1980 ft were buried below the level of the river bed. The overall length of the Purgatorie crossing was 582 ft with 282 ft representing the actual width of the river bed, and 382 ft were buried below river bed depth. The entire length of the South Canadian crossing including approaches was 7320 ft.

The line was coated over its entire length. From McKee to La Junta Somastic coating was applied and on the section from Borger to McKee a hot coal tar enamel was used. The Somastic coating was applied to pipe at railhead plants and enamel in the field. All joints were electric welded and the pipe was given an 18-in. cover. Test leads were installed in pairs, 100-ft spacing, approximately one mile between pairs. Cathodic protection (magnesium anodes) will be installed this spring or summer.

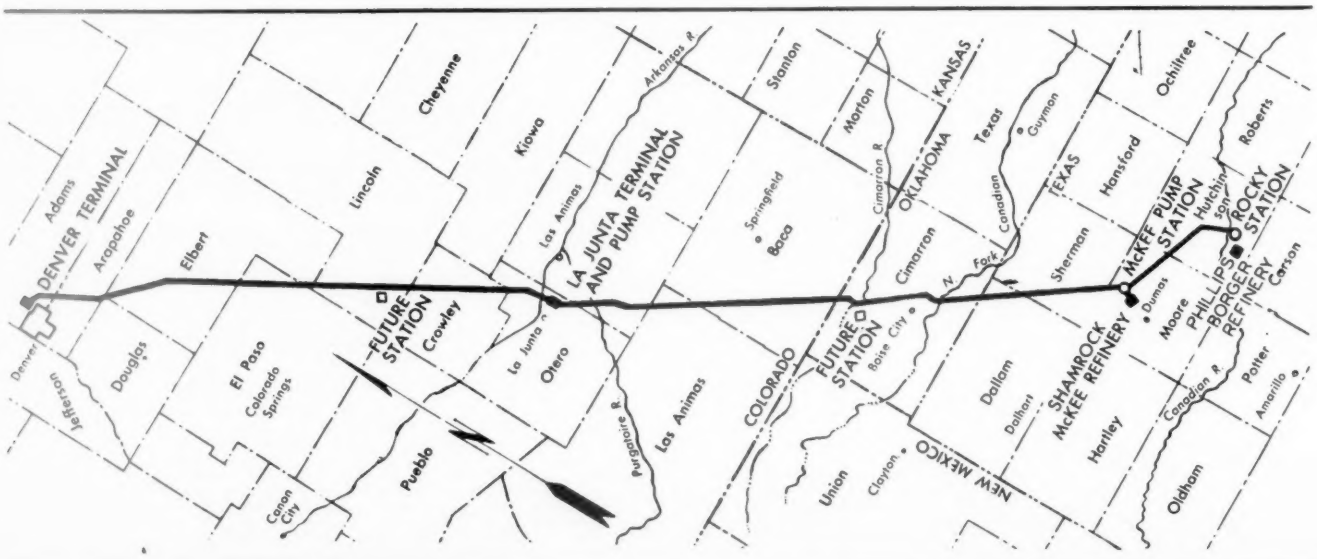
Each day the section of line laid was

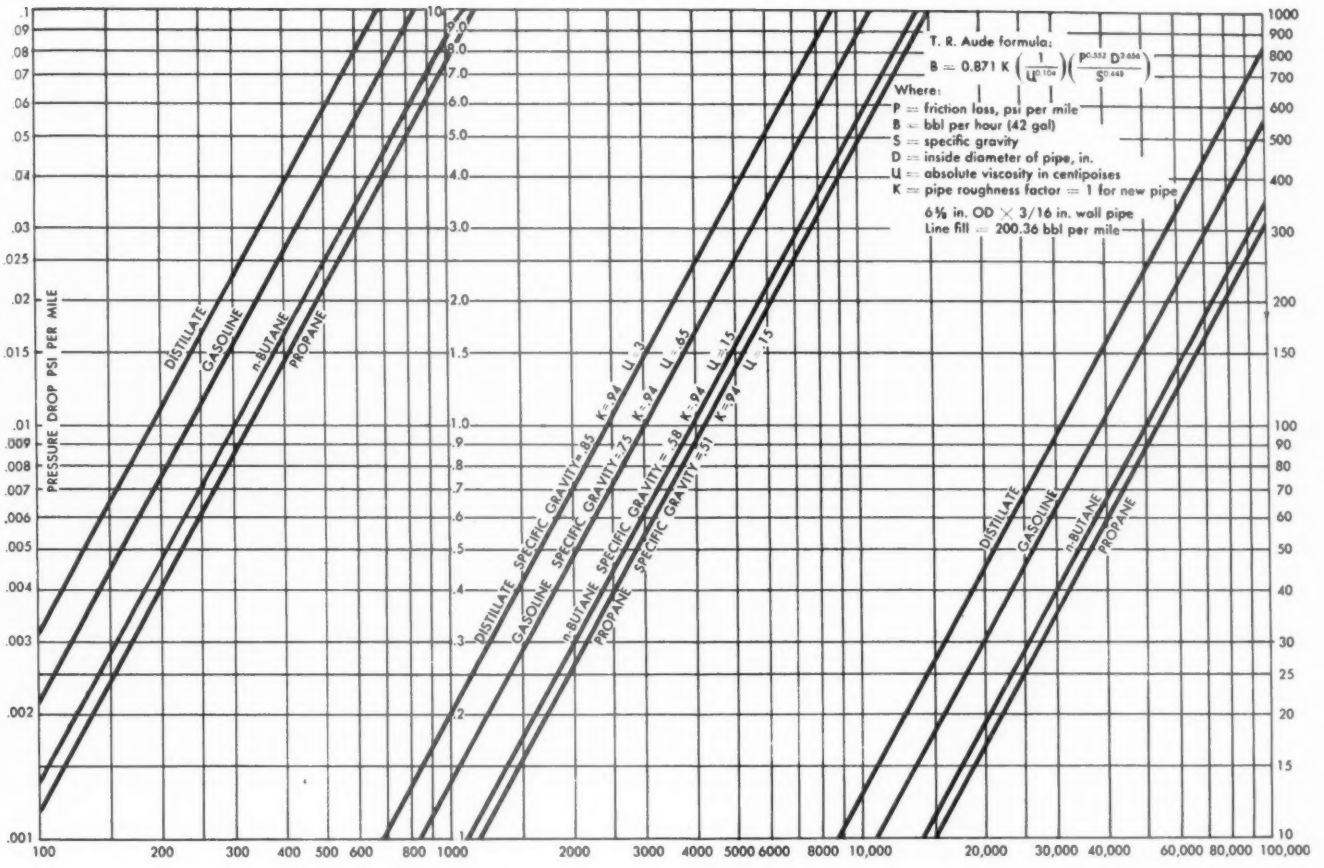


(Photo courtesy H. C. Price Company)

Railhead plant for applying Somastic coating to pipe.

ROUTE MAP.




T. R. Aude formula:
B = 0.871 K (1/U^0.104)((P^0.552 D^2.656)/S^0.448)
Where:
P = friction loss, psi per mile
B = bbl per hour (42 gal)
S = specific gravity
D = inside diameter of pipe, in.
U = absolute viscosity in centipoises
K = pipe roughness factor = 1 for new pipe
6⅝ in. OD × 3/16 in. wall pipe
Line fill = 200.36 bbl per mile
PRESSURE DROP PSI PER MILE
DISTILLATE
GASOLINE
n-BUTANE
PROPANE
DISTILLATE SPECIFIC GRAVITY=.85 K=.94 U=3
GASOLINE SPECIFIC GRAVITY=.75 K=.94 U=.65
n-BUTANE SPECIFIC GRAVITY=.58 K=.94 U=.15
PROPANE SPECIFIC GRAVITY=.51 K=.94 U=.13

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given a preliminary air test of 100 psi. A scraper was then run and the pipe lowered and backfilled. The final test was with gasoline at a pressure of 1600 psi, the line being allowed to stand under this pressure for 24 hr.

● **Station design.** The McKee station is situated in Moore County, Texas, about a mile north of Shamrock's McKee refinery, and is pumping products from that point into La Junta terminal. Products are received both from Shamrock and from Phillips at Borger.

Prime movers at this station consist of two triplex positive displacement pumps with variable stroke and one constant stroke unit. Each is driven by a 100-hp motor. One of the variable stroke units is used as a standby. Any future additions to the pumping equipment will be constant stroke units.

Normally the station will be pumping intermittently, based on intermittent pumping from Borger and the Shamrock refinery. As the product being pumped enters the station and before being metered it passes through one of two filters for removal of any free water or sediment. The metering arrangement consists of a felt strainer and positive displacement meter. There are two of these installations, either of which will handle the full stream. The meters will be proved periodically by means of a permanently installed proving tank.

After being metered the product goes through a gravitometer and sight glass, which are provided so that a change in the product being shipped can be determined either by variation in specific gravity or change in color.

Under normal operation the pumps are controlled either by a rate of flow controller, a discharge pressure controller, or a suction pressure controller. Each controller has a double duty air system, that is, one actuating mechanism, either pressure or flow, that operates simultaneously two air systems. The No. 1 air system is used to control the stroke of the variable stroke pumps, and the No. 2 system is for starting and stopping the constant stroke pump. Two air systems are used so that they may be independently adjusted for sensitivity and rate of reset. Each system consists of three instruments connected in series. Starting with the suction pressure controller, the output air goes to the air supply of the discharge pressure controller, the output air of which is the air supply for the rate of flow controller. The output of the rate of flow controller then goes to the pumping unit that is to be controlled. One air system goes to the stroke positioner of the variable stroke pump and the other to the starting relays of the constant stroke pump.

Normally the pumping units will operate on the rate of flow controller, but if the discharge pressure should exceed a preset maximum or the suction pressure should go below a preset minimum these instruments would assume control.

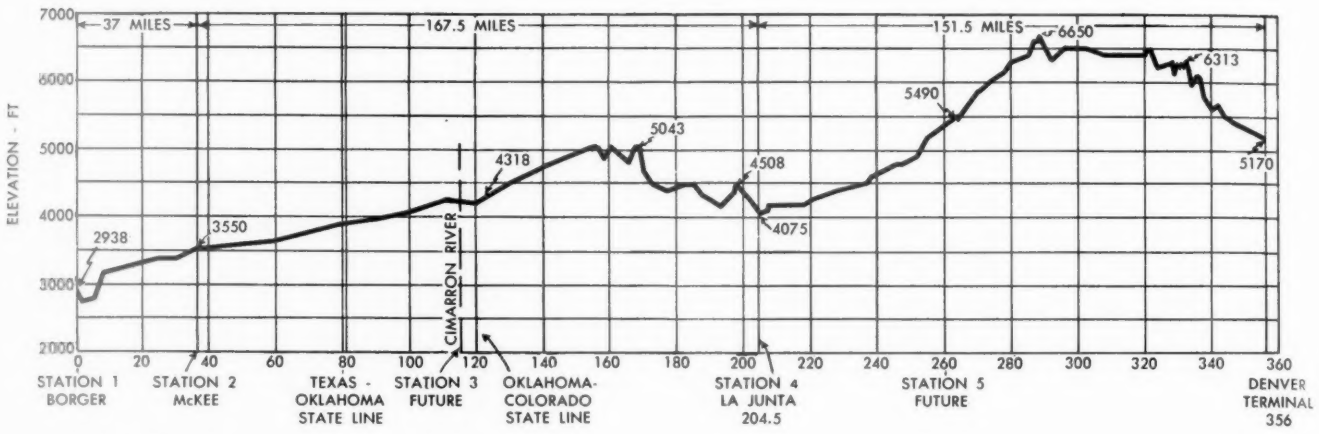
The Rocky station has this same control setup, as will the La Junta station when it is built, except that at the latter there will be no rate of flow controller because the flow rate will be determined by the McKee or Rocky station. Normally, the rate of flow controller will be utilized at McKee station only when pumping is from the Shamrock refinery. When pumping from the Rocky station at Borger that station will determine the rate of flow, and in that case the McKee station will operate on the suction or discharge pressure controller.

In addition to these operating controls there are a number of safety controls, as follows: (1) An independent underpressure alarm on the suction of the station, (2) a discharge overpressure alarm and shutdown, (3) an underpressure alarm on the instrument air system, and at McKee only (4) a pressure reducing control to limit intake pressure to 300 psi in event of a line shutoff.

At the Rocky station one variable stroke pump driven by a 100-hp motor has been installed. Inasmuch as it will be necessary for this station to operate only about 70 per cent of the time, a standby unit was not justified. This station, also, has the latest type automatic controls. No dehydration plant was installed here, however. Instead an inhibitor is introduced into the line to provide internal protection for the pipe between that station and McKee.

When the La Junta station is constructed, the equipment will be identical with that at the McKee station.

The pump building at McKee station is 20 ft by 56 ft by 12 ft, of which 40 ft



PIPE LINE PROFILE.

are devoted to the pumping equipment and 16 ft to the control room. Between the two sections there is a firewall that contains a full window. The building, which is insulated, has a steel frame and the siding is of cemesto board. During normal operation the pump room will be heated by heat from the motors, and the control room will be heated electrically. A standby electric heating system is provided for use when the pumping units are shut down. Other buildings at the plant, such as office and laboratory, warehouse, garage, and meter shed, are of similar construction although of different dimensions.

● **Terminals.** Provided at the La Junta terminal are a tank car loading rack with five spots, a truck loading dock, storage tanks, loading pumps, and an office and warehouse building. Later on this site a pumping station will be erected.

Positive displacement meters are used in truck loading. Controls on these meters make it possible to preset the gross gallonage to be delivered. The loading pumps are started, delivery made, and the pumps shut off automatically after which the net gallonage (with temperature compensated for) is printed on a ticket. Meters of this type are used for loading gasoline, distillate, and kerosine. LPG is metered by slip tube gauge.

All grades of gasoline are stored in floating roof tanks, distillates in cone roof tanks, and LPG in horizontal pressure vessels. At La Junta there is a total tankage of 90,500 bbl for gasolines and distillates, and 432,000 gal for propane. Each product tank has an individual pump and line extending to both loading racks.

The terminal at Denver will have total tankage of 125,000 bbl of gasolines and distillates and 336,000 gal of LPG. As at the La Junta terminal, separate loading docks will be provided for truck and tank car loading, and each storage tank will have an individual pump at the tank and a separate discharge line to the loading racks.

● **Flow formula and hydraulic data.** Prior to the beginning of construction, the matter of hydraulics was given extensive study because of the variety of products to be transported and the considerable variation in altitude of the line's route. After a flow formula was selected that best suited the circumstances, the Engineering Department of Phillips Petroleum Company prepared a report giving reasons for the particular choice. As this report contains basic data that well could be of value to others in the industry, it is included here in its entirety:

"With the variety of products to be handled in the 6-in. Borger-Denver products pipe line each having varying physical properties, it was necessary to employ an equation giving pressure drop in terms of rate of flow that would give satisfactory results regardless of the product being handled in the line.

"Hazen and Williams formula has been commonly employed in products line work by this company and others since 1930 with satisfactory results as long as products having approximately similar viscosities were handled.

"Hazen and Williams formula contains no variable to express the viscosity or internal friction of the fluid under consideration. Consequently, the value of "C" in the H&W formula, which is

Truck transport loading dock at La Junta, Colorado, terminal on the new products line.
(Photo courtesy Shamrock Oil & Gas Corporation)

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commonly thought of as an indication of pipe roughness, will vary with the product being handled in the same line when fluids of varying viscosities are pumped.

"It was our conclusion that the confusion that would be brought about by the use of a different H&W "C" factor for distillate flow than used for gasoline and a third "C" factor for LPG, fully justified departure from the Hazen and Williams formula to a formula that would as nearly as possible take into account all physical properties of each product being handled and that would contain a pipe condition factor to evaluate the internal condition of the pipe walls that would not vary with each different product pumped.

"It is known that the H&W formula is accurate for 0.75 sp gr gasoline having a viscosity of about 0.65 centipoises. We have knowledge of only two formulas other than Hazen and Williams containing a line condition coefficient that are suitable for all petroleum products from LPG to heavy crudes. These formulas are:

Benjamin Miller formula:

$$e = \frac{24B}{(4.06)\left(\frac{(d^5p)^{1/2}}{(g)}\right)(4.35 + \text{Log}\,d^3pg)\left(\frac{}{(u^2)}\right)}$$

T. R. Aude formula:

$$k = \frac{B}{0.871\left(\frac{(1)}{(u^{0.104})}\right)(p^{0.552}\quad d^{2.656})(\quad g^{0.448}\quad)}$$

e, k = pipe line condition factor ratio of capacity of existing line to perfectly smooth line.
B = rate of flow, bbl per hr.
p = friction loss, psi per mile.
d = inside diameter pipe, in.
g = specific gravity referred to water.
u = absolute viscosity in centipoises.

"Comparing the H&W formula, Miller, and Aude formulas using 0.75 sp gr gasoline and H&W "C" = 145 and a flow rate of 8000 bbl per day, it is determined that the corresponding values of e and k in Miller's and Aude's formulas, respectively, are 0.938 and 0.940. By inspection of the Miller formula it can be seen that its solution is cumbersome particularly when solving for rate of flow in terms of pressure drop. Accordingly the T. R. Aude formula was selected, for both formulas give very nearly the same results under similar conditions when the same values of e and k are employed. The Aude formula and the Hazen and Williams formula are in very close agreement for gasoline flow over the range of pumping rates involved in the Borger-Denver line design. A comparison of results by the two formulas follows:

H&W "C" = 145, Aude "k" = 0.94, 0.75 sp gr gasoline, u = 0.65 centipoises

Rate of flow, bbl per day	Pressure drop, psi per mile — Hazen & Williams formula	T. R. Aude formula	Percentage variation, H&W = 100%
3,000	0.945	0.980	+ 3.7
6,000	3.41	3.42	+ 0.3
9,000	7.18	7.18	0.0
12,000	12.2	12.2	0.0
15,000	18.2	17.9	− 0.2

"From the above table it is apparent that both formulas will give comparable results on gasoline.

"For distillates and LPG it can be shown mathematically that the H&W formula will give erroneous results, also, it can be shown theoretically that the Aude formula will give results that should agree very closely with actual line performance provided accurate viscosity data are available. As our research department can make viscosity determinations on both light and heavy hydrocarbons should it be found that the values heretofore used, taken from available data, are in error, it is thought that accurate information can be obtained.

"A comparison of the results obtained by Hazen and Williams formula and Aude's formula on distillate flow and LPG flow follows:

Pressure drop, psi per mile

Distillate, H&W "C" = 145, Aude "k" = 0.94

Rate of flow, bbl per day	Sp gr = 0.85, u = 3.0 centipoises — Hazen & Williams	T. R. Aude	Percentage variation, H&W = 100%
3,000	1.09	1.44	+32
6,000	3.9	5.05	+29
9,000	8.2	10.6	+29
12,000	14.0	17.8	+27
15,000	21.2	26.5	+25

Pressure drop, psi per mile

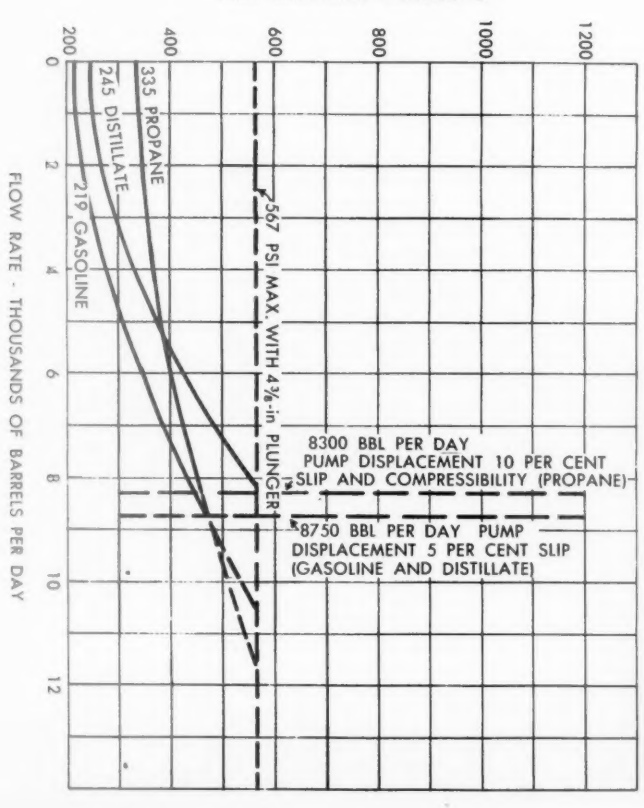
Propane, H&W "C" = 145, Aude "k" = 0.94

Rate of flow, bbl per day	Sp gr = 0.51, u = 0.15 centipoises — Hazen & Williams	T. R. Aude	Percentage variation, H&W = 100%
3,000	.62	.54	−15
6,000	2.3	1.90	−17
9,000	4.9	3.95	−19
12,000	8.3	6.7	−19
15,000	12.5	10.0	−20

"It is our opinion that the H&W formula will give insufficient pressure drop per mile for distillates and pressure drops in excess of those actually realized for propane flow in the approximate amounts shown by the above table.

"This is further borne out by com-

Pipe line system curve—Borger to McKee.



Applying coating over welded joints in the field.

(Photo courtesy H. C. Price Company)

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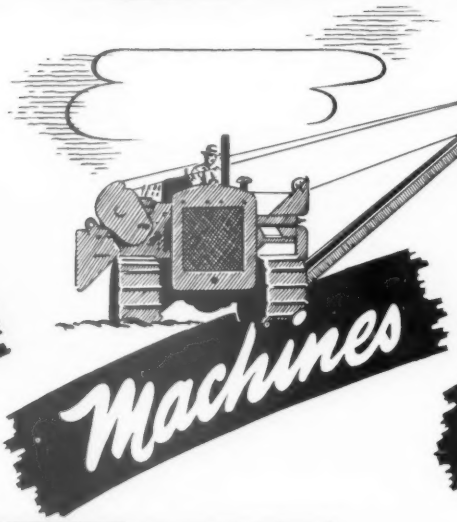

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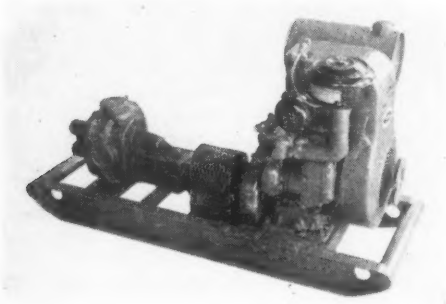

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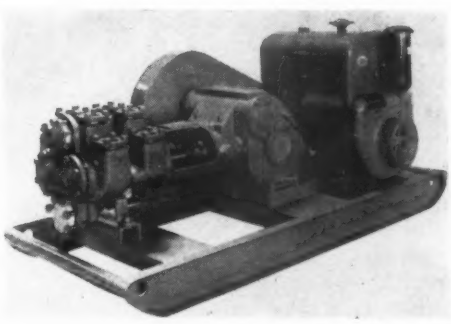
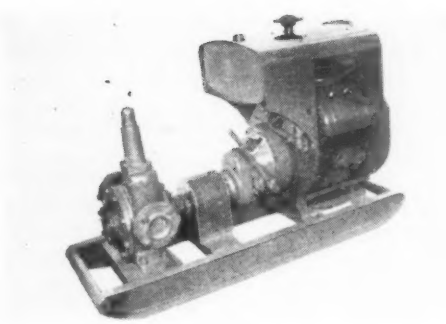
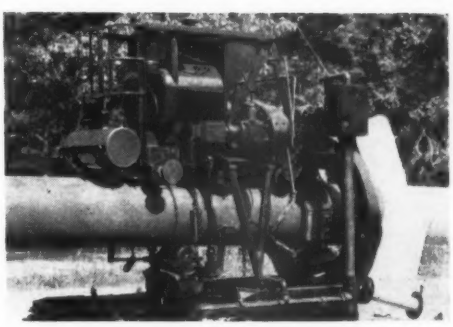
Power Range
2 H.P. to 30 H.P.







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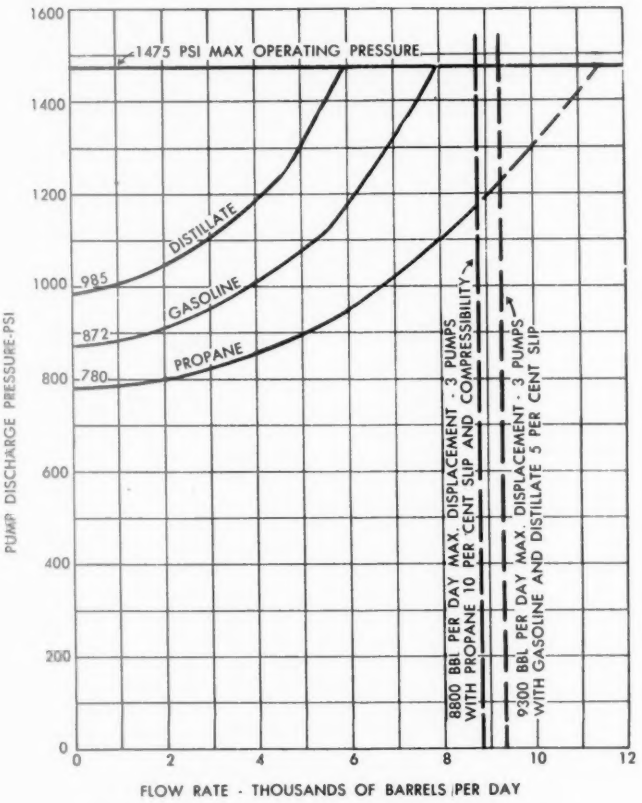
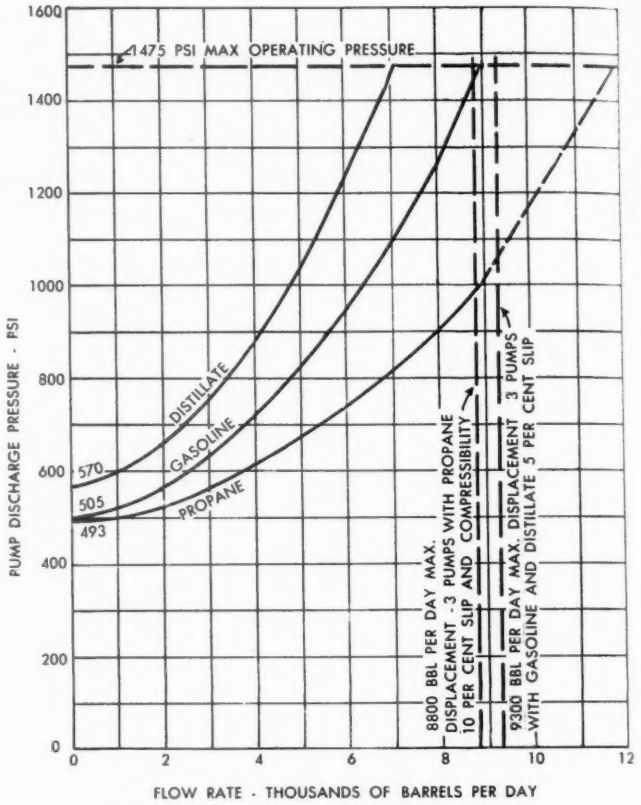

1475 PSI MAX OPERATING PRESSURE
DISTILLATE
GASOLINE
PROPANE
985
872
780
8800 BBL PER DAY MAX. DISPLACEMENT - 3 PUMPS WITH PROPANE 10 PER CENT SLIP AND COMPRESSIBILITY
9300 BBL PER DAY MAX. DISPLACEMENT - 3 PUMPS WITH GASOLINE AND DISTILLATE 5 PER CENT SLIP
PUMP DISCHARGE PRESSURE-PSI
FLOW RATE - THOUSANDS OF BARRELS PER DAY

Pipe line system curve—LaJunta to Denver.


1475 PSI MAX OPERATING PRESSURE
DISTILLATE
GASOLINE
PROPANE
570
505
493
8800 BBL PER DAY MAX. DISPLACEMENT - 3 PUMPS WITH PROPANE 10 PER CENT SLIP AND COMPRESSIBILITY
9300 BBL PER DAY MAX. DISPLACEMENT 3 PUMPS WITH GASOLINE AND DISTILLATE 5 PER CENT SLIP
PUMP DISCHARGE PRESSURE - PSI
FLOW RATE - THOUSANDS OF BARRELS PER DAY

Pipe line system curve—McKee to LaJunta.

parison of Aude's formula with results obtained using the Fanning formula recommended by Crane Co. in its technical paper No. 409. The two formulas are in very close agreement.

"The accompanying graph giving pressure drop in terms of rate of flow for 6.25 in. ID pipe shows this relationship as calculated by Aude's formula for distillate, gasoline, and propane flow. On one of the accompanying graphs are shown the corresponding relationship of pressure drop and flow calculated by Hazen and Williams formula. In both formulas equivalent values for pipe roughness have been employed (H&W "C" = 145, Aude "k" = 0.94).

"Head capacity curves for each section of the pipe line have been prepared and these curves are also shown. The head capacity curves show the pressure required to pump a given volume of gasoline, propane, or distillate from Borger to McKee, McKee to La Junta, and La Junta to Denver, respectively. The position of the lines on the pressure axis at no flow indicates the static head at each station. On the Borger-McKee chart the distillate curve intersects the horizontal 567 psi line at 8100 bbl per day, at which pumping rate the maximum frame loading of the pump is reached. On the propane curve the volumetric capacity of the pump allowing 5 per cent slip and 5 per cent compressibility is reached at 8300 bbl per day. Although the line pressure drop is insufficient to exceed the maximum pump frame loading, the gasoline curve reaches the volumetric capacity of the pump at 8750 bbl per day allowing 5 per cent slip.

"On the McKee-La Junta chart the static at McKee, assuming the line filled with at least 131 miles of the one product down stream from McKee to the highest elevation in this section, will be shown on the pressure scale at no flow plus an amount of 20 psi additional for gasoline and distillates and 200 psi for propane, these quantities being judged minimum required to prevent subatmospheric pressures or pressures less than product vapor pressure at the point of highest elevation between McKee and La Junta at mile 168 shown on the accompanying profile map.

"The pumping rate on distillate is limited to about 7000 bbl per day, at which point the allowable stress in the pipe is exceeded. The maximum pumping rate on gasoline is limited to 8900 bbl per day for the same reason. The maximum pumping capacity on propane is 8800 bbl per day due to volumetric capacity of the pumps 5 per cent slip and 5 per cent compressibility.

"It will be noted that changes in slope on these curves occur at about 8900 bbl per day on propane, 8050 bbl per day on gasoline, and 6900 bbl per day on distillate. These breaks are brought about by an intermediate point of greater elevation than the delivering and receiving points. For example, between McKee and La Junta at mile 168, the ground elevation is 5043 ft, 1493 ft higher than McKee station and 968 ft higher than La Junta station. At low flow rates the potential energy in the fluid when it reaches mile 168 is greater than the energy required to move the fluid from 168 to La Junta pump station because the resistance to flow due to pipe line friction in 36.5 miles of line is less than the 968 ft static head available from mile 168 to La Junta. Consequently, at low flow rates the pipe friction between McKee and La Junta may be considered as only being effective over the section between McKee station and mile 168, or 131.0 miles instead of the entire distance of 167.5 miles.

"The pressure at mile 168 will be at the lowest practicable minimum; under these conditions we have used a figure of 20 psi for gasoline and distillates and 200 psi for propane. In the case of gasoline, when the flow rate reaches 8050 bbl per day the pipe friction will equal the static head available between mile 168 and La Junta station and the pressure capacity curves will have a steeper slope at flow rates greater than 8050 bbl per day, since the pressure drop due to line friction must now be considered over the entire 167.5 miles of line. A similar circumstance causes the break in the head capacity system curves for the section from La Junta to Denver."

● **Operators and contractors.** The new line is being operated by the Products Pipe Line Department of the Supply and Transportation Department of Phillips Petroleum Company. Engineering work was by the Engineering Department of Phillips, personnel of which designed the line and supervised construction. Stations were built by Phillips personnel. H. C. Liles Construction Company had the contract for the line from McKee to La Junta, and Albert C. Johnson the section from Borger to McKee.

★ ★ ★

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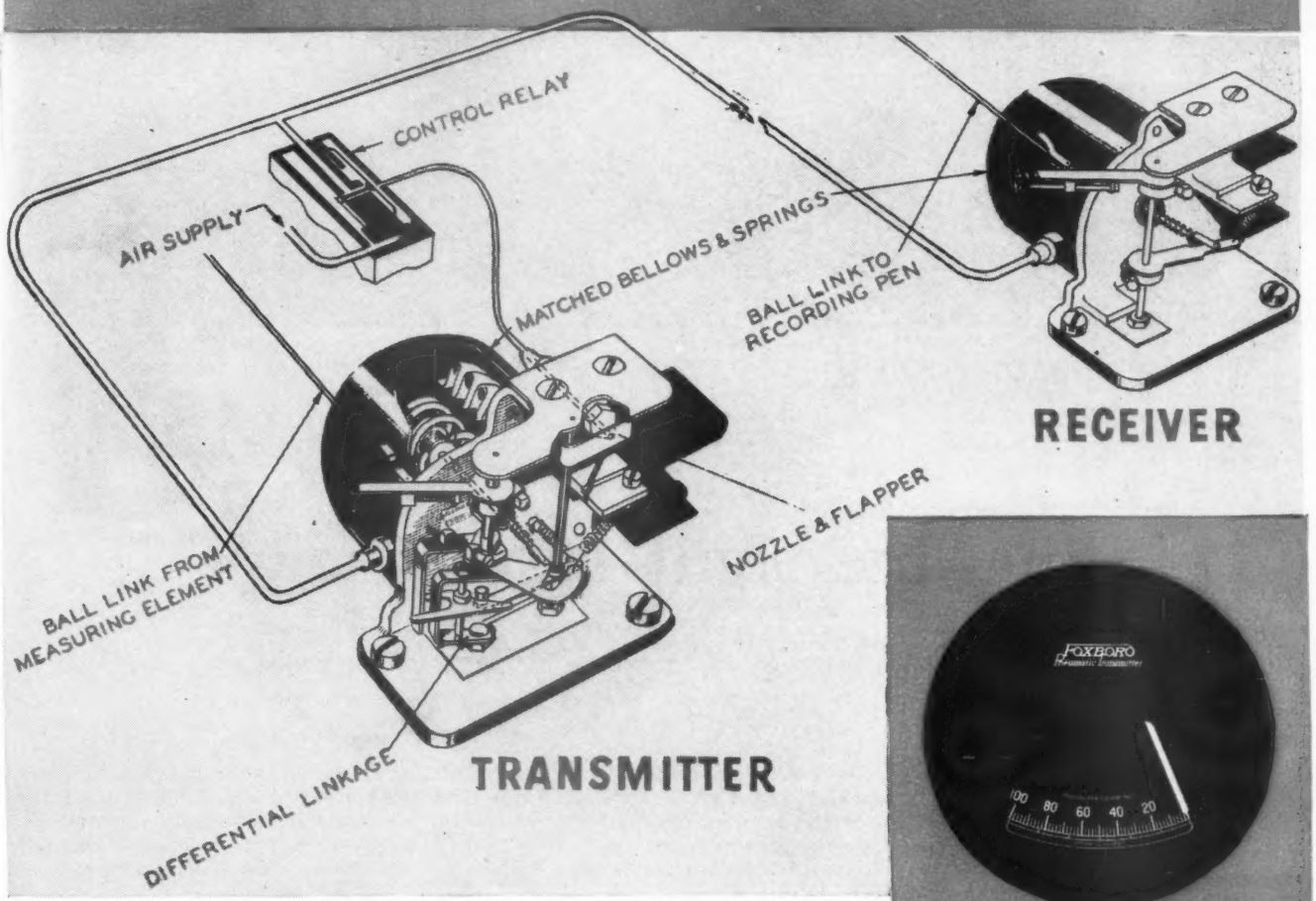

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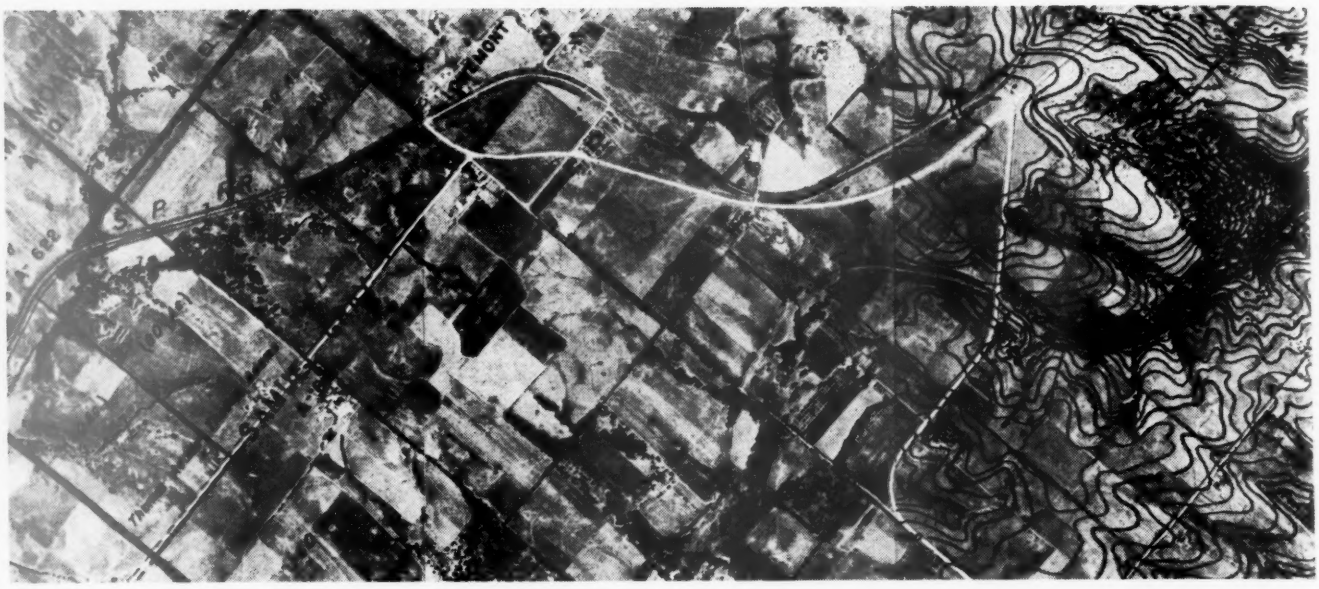

FIG. 1. Multiple purpose map showing portions of property ownership and topographic overlays on base mosaic.

Pipe line right-of-way maps

By ELLIS W. CLARK, *Engineer*, Jack Ammann Photogrammetric Engineers

THE economic objective of all pipe line operators is to get a "cheap ditch". With the current high cost of pipe and labor, it is no longer feasible, or sound business, to initiate heavy construction projects such as pipe lines except on the basis of complete compilation of planning and operational data. Considering the cost of pipe alone, it would not take many miles of poor judgment in route alignment, or many miles of unnecessary heavy swamping, to boost construction estimates to the extent that a project could not be underaken.

EXCLUSIVE

Whether the proposed pipe line is transcontinental or interstate, the basic problems of engineering and design are the same. The location of any route still involves a complete study of all available data to determine the manner in which certain definite requirements of the enterprise may be met at the least expense, including not only the cost of route surveys and construction, but also the cost of maintenance and operation.

The accuracy of route surveys and location studies for prewar pipe lines, as conducted by conventional ground methods, cannot be questioned; but undoubtedly one of the greatest contributions of the decade to the petroleum industry in general, and pipe line planning in particular, has been the application of photogrammetry. The steadily increasing use today of aerial surveys in engineering and geologic fields is a logical development, for the application of photogrammetry provides many advantages over the arduous ground survey methods in (1) saving in time of months or years, (2) a more thorough and complete survey, (3) greater overall economy, (4) availability of data not obtainable economically by other methods.

In conventional ground methods, the compilation and recording of engineering and planning data is the result of what the field man sees, and of his ability to record what he sees. The aerial survey provides a permanent record of the earth's surface, in complete detail, for all present and future reference, study, analysis, and interpretation. A wealth of information is obtained by photogrammetric processes that might otherwise be neglected because of the areas involved, the time element, and the high cost of preliminary and final route surveys by conventional methods. Without question the aerial survey will eliminate a vast amount of expense and delay in preliminary surveys and planning and effect still more economies in the elimination of errors of design and estimate of costs, due to insufficient overall information.

For the right-of-way engineers of the petroleum industry, the most useful by-product of the aerial survey is in the compilation of "multiple purpose maps," as illustrated in the above photo, Fig 1.

An aerial photograph, or a controlled composite of photographs into a mosaic, is a pictorial representation of the earth and its features. A topographic map, or a property ownership map, or any other special purpose map, is a representation of certain required features or data, any of which, as an individual unit, does not represent a complete map. By the combination of these units into registered overlays we obtain the multiple purpose map.

The multiple purpose map as originated by the Jack Ammann Photogrammetric Engineers, consists of a controlled mosaic base map, to which in perfect register can be superimposed various overlays showing topography, property ownership, or any other special purpose map required in right-of-way location and pipe line construction or maintenance. A very important component of the multiple purpose map would be the inclusion of a photographic reproduction of the mosaic on a plan and profile sheet, on which preliminary routes and vertical profiles could be plotted. Thus the planning executives, right-of-way departments, land and legal departments, or construction and maintenance departments, have before them in graphic form a complete compilation of all data required.

For engineering, land, or legal work, mosaics or maps made from controlled

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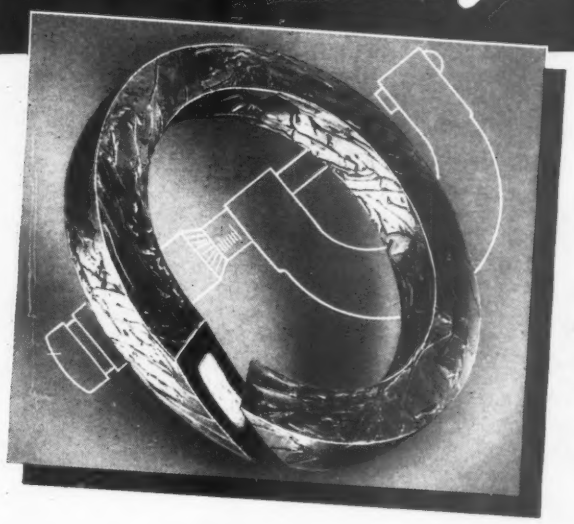

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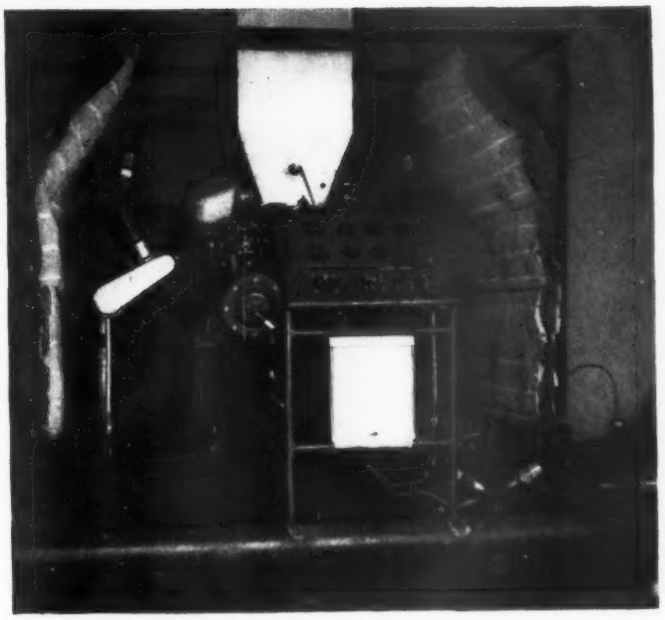
AIRCRAFT ENGINES
"Pinch-hit" in pipe line service to help ease shortage



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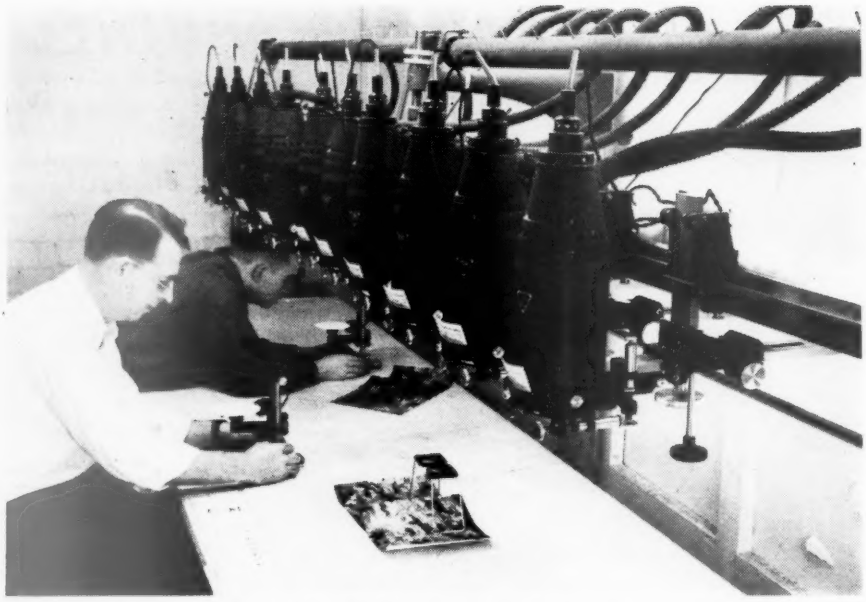


FIG. 2. Wide angle Multiplex aeroprojectors in operation.

mosaics provide basic data that are complete in all cultural detail. They possess the advantage, unusual in maps made by ordinary ground methods, of representing the culture on the surface of the earth as it actually is, and on them the engineer may readily solve his problems without fear of unforseen or unknown geographic or geological obstructions.

With the multiple purpose map, the planning engineer has a pictorial representation of every road, house, tree, fence, or cultural feature within his area of operations. Correlated to this, he has a complete record of the physiographical problems involved and a key to all property ownership.

With complete maps of this nature, the engineer can do all preliminary planning without expensive field parties, or the premature disclosure of plans or objectives. When the right-of-way man is ready, he can proceed unhandicapped by the publicity attending survey and location on the ground. The actual ground survey following the acquisition of easement rights, is limited to the final location of the ditch centerline, which can be laid out for any section independent of a continuous or geodetically controlled center line. These can all be previously correlated and planned in the office from a study and analysis of the multiple purpose map.

Modern topographic mapping from aerial surveys is accomplished by the use of Multiplex aeroprojectors by the Jack Ammann Photogrammetric Engineers as one of the exclusive users in the United States (see Fig. 2). Through the medium of this scientifically designed method, the aerial photograph is placed in the same relative position as when the exposure was made from the airplane. Through this procedure, the exact model of the earth's surface is used as the base for representing topographic features. The most skillful ground topographer is unable to form contours so accurately but that they can be materially improved by the use of aerial photographs and the Multiplex method. Nor can the most skillful planetable topographer compete with the Multiplex aerial method in overall accuracy, coverage of planimetric and topographic detail, or costs in producing the final map.

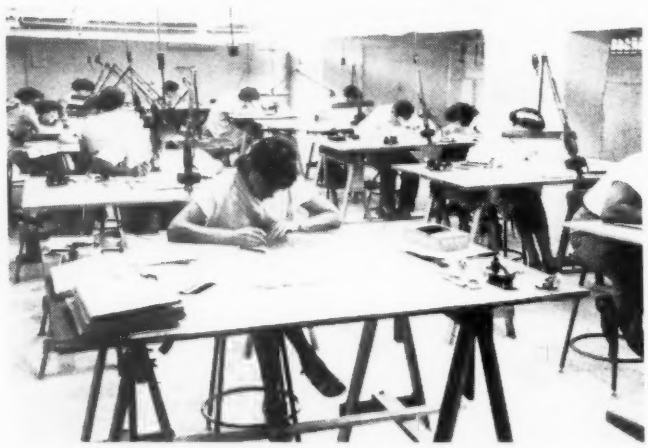
Property ownership maps cannot be accurately constructed from deed descriptions and survey records alone, because such information does not take into consideration the actual occupation of the land. For the compilation of property and fee ownership maps of the type illustrated on the left of Fig. 1, the following elements of construction are involved: (1) Exhaustive search, and accurate comprehensive annotation of the county records, (2) reconciliation of the record discrepancies with the true land base by adjustment-plotting of the property record notes on the controlled mosaic base, (see Fig. 3), and (3) examination and settlement by field engineers of numerous occupancy problems not to be solved from photographic maps.

The basic multiple purpose map to be used in pipe line construction, or in any type of route planning, should be one that incorporates the very latest aerial photography. Any initial aerial survey, as engineered for any type of application, should not be considered as a cheap temporary expedient. The photography expense should be weighed against the up to the minute ground detail obtained. Then with the assistance of experienced photogrammetric engineers to design the photographic specifications to meet the requirements of the job, the total cost of the aerial survey can be held to the minimum.

The total cost of an aerial survey and the production of multiple purpose maps cannot, and should not, be charged off to any individual operation. The multiple purpose map, as the name implies, will serve multiple uses throughout the life of the pipe line, from preliminary planning to final abandonment. Although in many instances the total cost of the aerial maps has been written off through operational savings resulting from the elimination of unnecessary activity in

Fig. 3. Compilation of property ownership map.

FIG. 4. Drafting room equipped with all facilities for modern mapping.



any one department, such as the saving of a booster station.

Although primarily designed for modern right-of-way engineering, the adaptability and utility of the multiple purpose map as produced by the Jack Ammann Photogrammetric Engineers can be briefly explained as follows:

(A). Preliminary planning. With the mosaic base and accompanying overlays on topography and property ownership, the engineer has before him all data required for preliminary planning. With the inclusion of a work sheet consisting of a photographic reproduction of the mosaic and cross-section layout, the engineer can plot preliminary vertical profiles at all possible locations. After the final route location has been decided the centerline can be plotted on the mosaic.

(B). Preliminary cost estimating. As the location of every tree, creek, swamp, or other cultural and topographic feature is presented on the multiple purpose map, accurate estimation of construction costs is possible without field investigation of ground conditions. Pumping, or boosting, stations can be accurately planned for, and designed to meet known conditions. Costs of gravity lines can be estimated accurately.

(C). Acquisition of right-of-way easements. From the multiple purpose map, the land man has all the facilities to plan properly his program of activity without publicity, or disclosure of plans.

(D). Field surveys. As the preliminary planning has been done in the office, the only field surveys required would be the actual staking out of the centerline, as indicated on the base mosaic by the planning engineer. The staking may be done on any isolated section on which construction can begin.

(E). Construction. From the base mosaic the construction engineer has a pictorial representation of all ground conditions in his area of operation. From this he can solve all transportation problems involved in the disposition of pipe and materials. He can save time and expense in knowing the terrain available for trucking and movement of equipment. He can also more adequately plan his operations, and the labor required to do the job.

(F). Maintenance. If the maintenance superintendent is supplied with a copy of the multiple purpose map, he will have all the data required for the planning of his maintenance function. For example, if a break should occur at a creek crossing, he can immediately determine the high water conditions in the area, the most accessible way to get there, and knowing what the ground conditions will be he can estimate what labor and materials will be required.

(G). Progress reports and operational data. Progress in construction as outlined on the base mosaic offers the ideal method of preparing progress reports to the executive offices, as it visually portrays all ground conditions relative to the job. The multiple purpose map also can continue to serve as basic data in executive planning for improvements, expansion, and servicing of nearby future customers. ★ ★ ★

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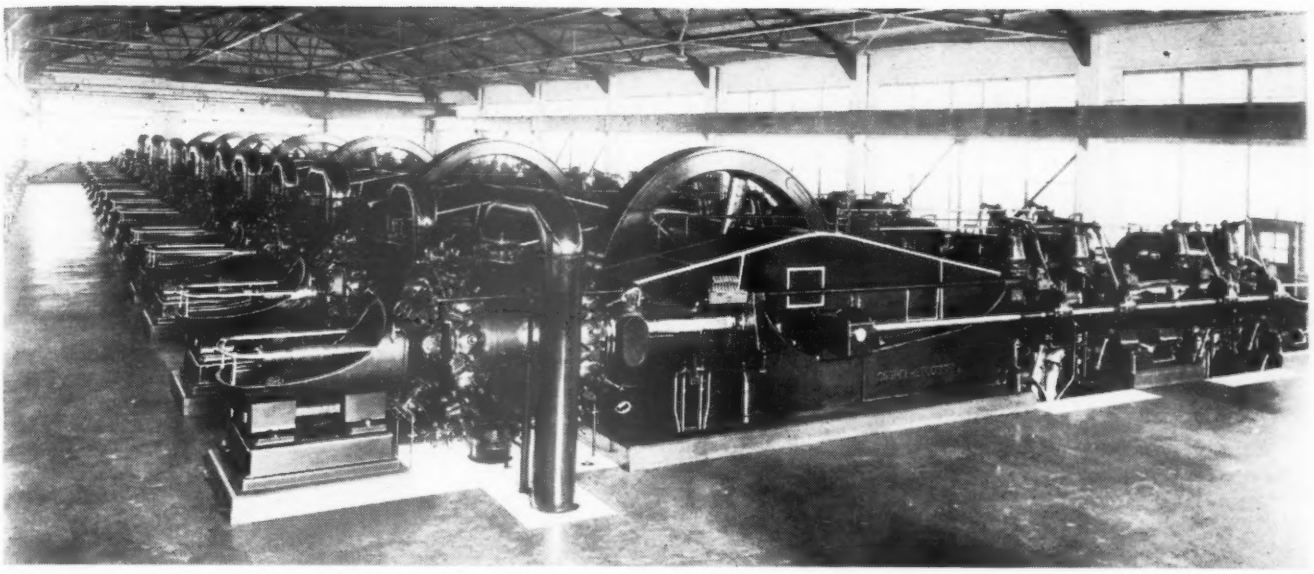


FIG. 1. Seven twin tandem horizontal compressor units, each developing 1600 hp in natural gas processing plant.

Modern gas pipe line compressors

By RALPH L. BOYER, *Vice President and Chief Engineer,* The Cooper-Bessemer Corporation

PARALLEL with many other developments in the industry the gas pipe line compressor has made great advances in a relatively few years. For that reason it is believed to be worth while to take stock of some of the accomplishments.

EXCLUSIVE

There is as yet a certain reluctance on the part of some engine users to accept the most modern developments. This conservatism is fully appreciated. I represent an engine builder that is in a particularly enviable position in this matter for we have built gas compressors from practically the beginning of gas pipe lines. We still build the large, slow-speed horizontal compressors, along with what we consider as more modern equipment. We expect to continue to respect the desires of those favoring the heavier, slower machinery, but we believe the time has arrived when we should report on what has been and can be accomplished with higher speed machinery.

When we get right down to facts, we are all influenced over a period of years almost exclusively by cost of operation. If we think in terms of maintenance, reliability, etc., they still reflect themselves eventually in terms of cost. This cost of operation is probably logically confined to first cost, fuel cost, maintenance and labor, and supervision. The purpose of this article is to make a few comparisons of these various figures, staying strictly within the products we manufacture and making no attempt to compare our accomplishments with that of any competition.

● **First cost.** In making any comparison of first cost, it is necessary to take into account the sizes of different types of machinery. Quite logically, other things being equal, the larger the compressor unit in horsepower the less will be the first cost in dollars per horsepower. Furthermore, a large compressor station can be installed for some less dollars per horsepower than a smaller one. In order to make a reasonably accurate comparison we have assumed a station of 10,000 hp and we have further assumed 1600-hp units whether horizontal or angle type. This size of unit is selected because 1600 hp is the largest horizontal unit available. That is not the largest size angle engine available, as there is an angle engine of 2400 hp. Obviously, if we were to use the 2400-hp angle the story would be changed considerably and the figures would be much more in favor of the angle engine. Cost per horsepower has been figured at $66 for both types of compressors, again giving the advantage to the horizontal unit. These facts should be borne in mind, therefore, in studying the following comparisons.

A thorough study has been made in the field and it is believed that these figures are truly representative of present-day practice.

	Horizontals	Angles
Labor	$ 587,500	$ 417,500
Material	1,375,000	1,188,750
Expense	55,000	50,000
Contractor's	125,000	81,250
(The above are direct expenses, to which should be added company engineering, overhead, sales tax, interest on investments during construction, totaling 15 per cent of each figure.)		
Total cost	$2,463,875	$1,998,125

It will be noted that the above represents a saving of more than $40 per hp in favor of the modern engine. In all fairness to the angle type engine, however, attention must be drawn to the fact that the stations are not exactly the same kind. For example, the cooling system of the horizontal station calculated above is with raw water, atmospheric tower, 10,000-gal storage tank, whereas that figured in the above station for angle engines is a closed water system. Furthermore, the field figures show that the auxiliary generator capacity for the horizontal station should be about 375 kw, as against about 75 kw for the modern engine. The reason for this is that the water pumps are figured as being direct connected to the angle engines, whereas they are all motor-driven for the horizontal engines.

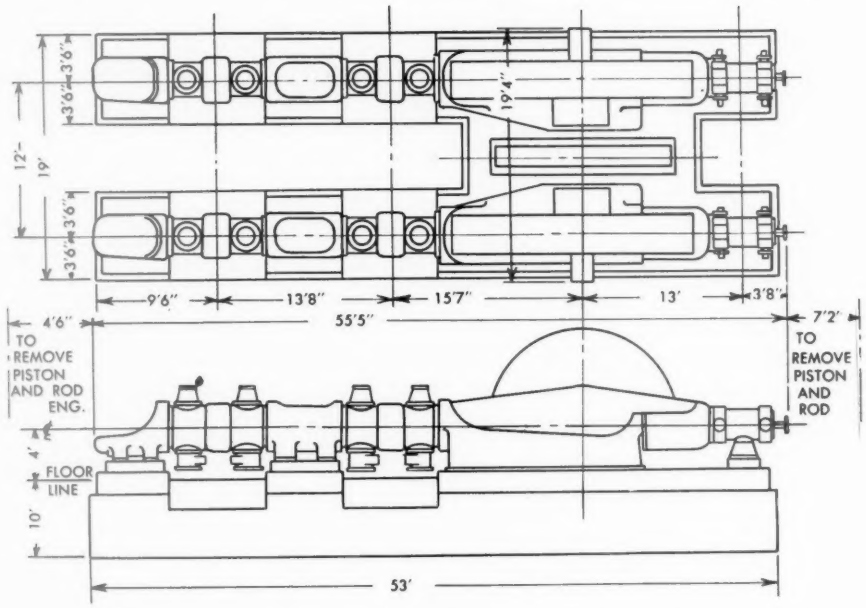


FIG. 2. Space plan drawing showing dimensions of 1600-hp, 4-cycle horizontal compressor unit.

In these figures no dwellings are included. Garages are figured in each case, as are also the plant site, roads, temporary roads, and everything required to construct the plant. The building for the above horizontal engines for the 10,000-hp compressor station is calculated as 72 ft by 175 ft. For the angle engines it is 40 ft by 175 ft. For the horizontal engines, 5250 cu yd of concrete are figured, as against 3000 cu yd for the angle engines. The cost of the factory erector is put in the same for each, and the additional labor for erecting the engines is calculated at $6000 per unit for the horizontals and $2000 per unit for the angle engines.

We must point out again that in spite of the very favorable showing, we have not used our largest engine in making this comparison and if we were to use it the story would be considerably more favorable.

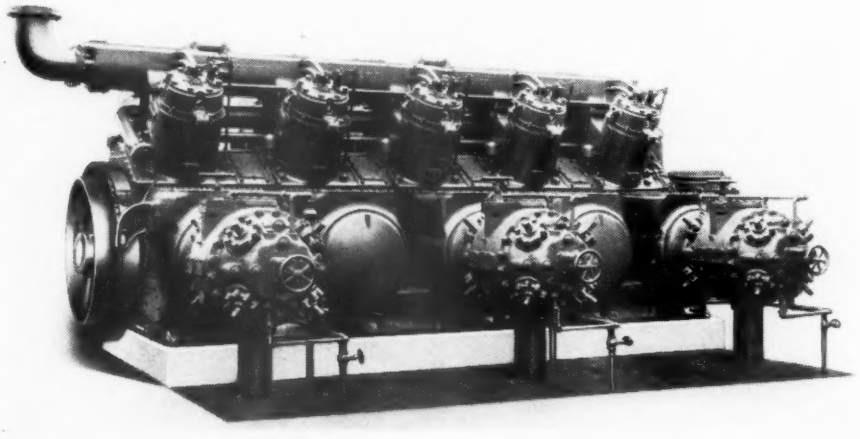
● **Fuel cost.** For many years the accepted fuel consumption of the standard slow speed, 4-cycle, double-acting engine was 10 cu ft, or 10,000 Btu's, per bhp-hr. Improvements were made until it was possible to guarantee 9500 Btu's per bhp-hr on this type of engine. In the meantime, the original simple 2-cycle engines were high fuel gas consumers. It hasn't been too many years ago that a 2-cycle engine took at least 15,000 Btu's per bhp-hr. Various improvements were made until it was finally leveled off for several years at 10,000 Btu's, never quite as good as its 4-cycle competitor. Recently we have been able to effect major improvements, which are now enabling us to guarantee 8500 Btu's per bhp-hr on the 2-cycle gas compressor. A graphic history of the progress toward lower fuel consumption and higher ratings is given in Fig. 9.

We also present Fig. 10, which is an actual curve of fuel consumption of the horizontal double-acting engine versus recent 2-cycle compressor performance versus this most modern development, which we have chosen to call "Turboflow." It will be noted that the Turboflow engine actually does considerably better than 8500 Btu's, which we have chosen as a guarantee figure.

There was a time when fuel consumption of a gas compressor engine wasn't considered of too much importance; however, it has become one of the major factors in the cost of operation of a pipe line. If we consider a 10,000-hp pipe line station, then the recent 2-cycle performance would require 100,000 cu ft of fuel gas per hr, whereas the horizontal double-acting engine would require 95,000 cu ft, and the Turboflow engine would require 85,000 cu ft. In other words, the Turboflow engine represents a saving of 15 per cent over other 2-cycle performance and a saving of 10½ per cent over the best 4-cycle performance. When we think in terms of a pipe line of 200,000 hp, which isn't anything unusual today, this latest type compressor would save 300,000 cu ft of gas per hr. When attempting to get some idea about what this fuel gas is worth, one is likely to get as many answers as people asked, for it varies so widely in value. At the field end of a line, gas may be worth, we know, no more than 10 cents per M cu ft, whereas at the consumer end of the line it is actually worth whatever the consumer pays for it. At 10 cents per M cu ft for the above 200,000-hp line there would be a saving of $30 an hr, or $263,000 per year. Obviously, if this gas is worth 20 cents, then the figure becomes $526,000 per year, etc. At even 10 cents per M cu ft this modern 2-cycle engine would save $175,000 per year over the horizontal slower speed practice. It is obvious, therefore, that fuel economy has become of major importance in the cost of operation of a pipe line.

● **Maintenance.** We are sure that it has been definitely established that the maintenance cost of the modern higher speed engine is no greater than that of its large horizontal competitor. I am not sure that it is fair to say that the reliability of the angle machine is quite equal to that of the horizontal engine, if one considers a pipe line that operates on the older principle of pumping gas through the winter and being comparatively idle during the summer when overhauling can be done without too much haste. In other words, it may be that through a season one cannot be quite so sure of an angle machine staying continuously on the line as a horizontal machine, although it is close enough in performance to the horizontal machine that there isn't actually much difference. The horizontal machine usually requires an annual overhaul, which was thought of formerly as being done in the off season. This overhaul requires 10 to 14 days. The reason for the time is apparent when one sees the major parts that must be handled and the difficulty of getting at

FIG. 3. This 10-cylinder Type GMV is a 2-cycle compressor unit developing 100 hp per cylinder. V-angle construction provides compactness and versatility of five compressor drives.



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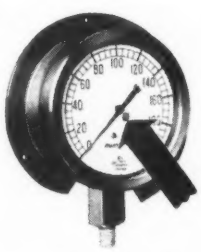

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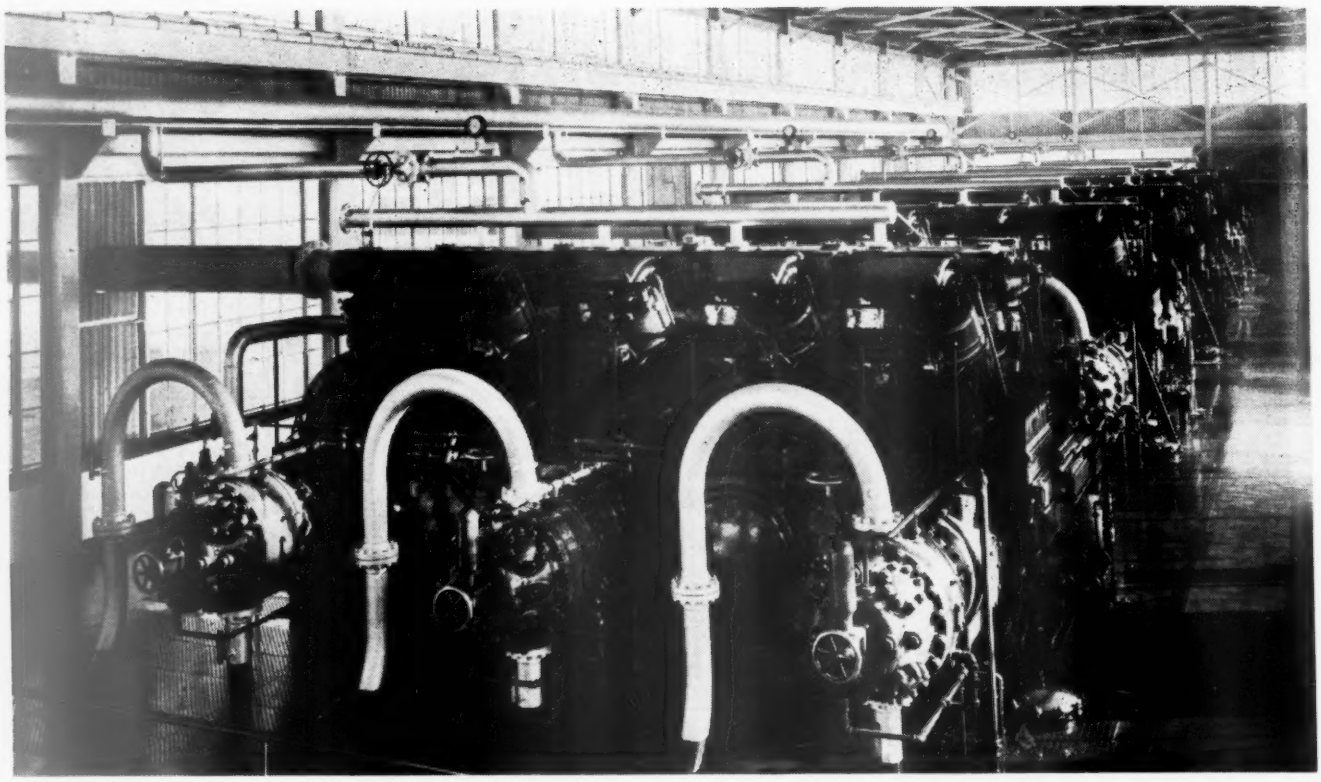


FIG. 4. Five 10-cylinder GMV's provide 5000 compressor hp in a station on one of the major gas pipe lines.

FIG. 5. Right, space plan drawing showing dimensions of 1000-hp, 2-cycle V-angle compressor unit.

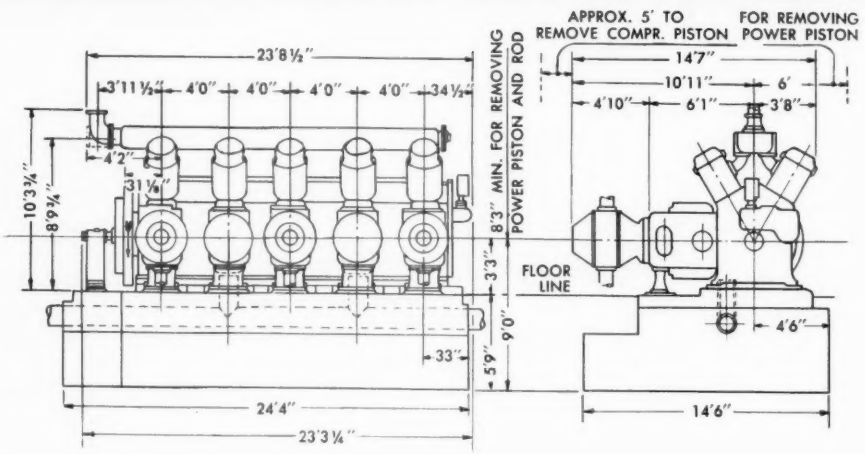
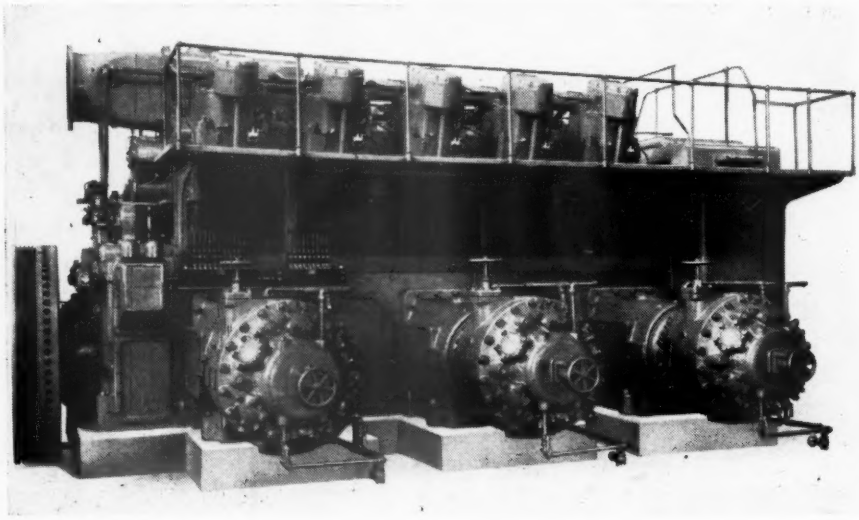


FIG. 6. V-Angle Type GMW is 2-cycle unit, 2400 hp in 10-cylinder model. All crankthrows can be utilized for compressor drives by mounting compressors on both sides of engine.



some of them. As compared to this, the major overhauling of an angle engine is usually accomplished in four or five days.

An interesting slant is that most pipe lines no longer have an off season. When the gas isn't being consumed it is usually being stored, so as to have available a greater supply during the following winter season. No longer do we find it possible to have an overhaul season during which time the job may be done more or less leisurely. Overhauling on the contrary, has become largely a matter of progressive maintenance. Progressive maintenance isn't very workable in the large horizontal engine because it is too much of a major job to remove any one piston, or cylinder, for example. Contrasted to this, the removal or replacement of a piston or cylinder on the angle engine is a very short job. I believe it is largely because of this feature that the angle engine has the reputation of not being quite so reliable during the season as the horizontal engine used to be. Even if this were true, it may be seen from the first cost previously discussed that an additional angle engine might well be installed as a standby to more than provide for any difference in reliability and still be a more economical proposition. We should not lose sight of the fact that the failure of any one part of an angle machine represents a very small

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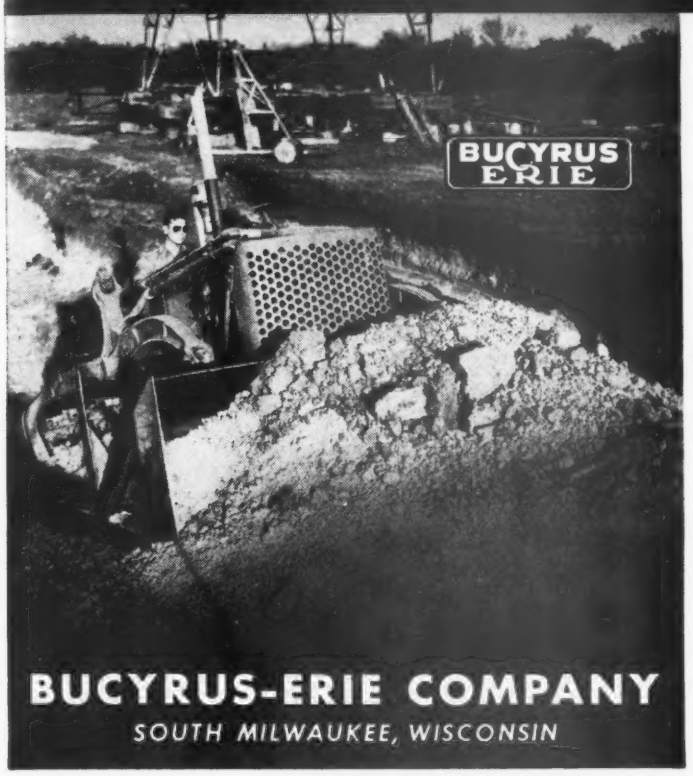

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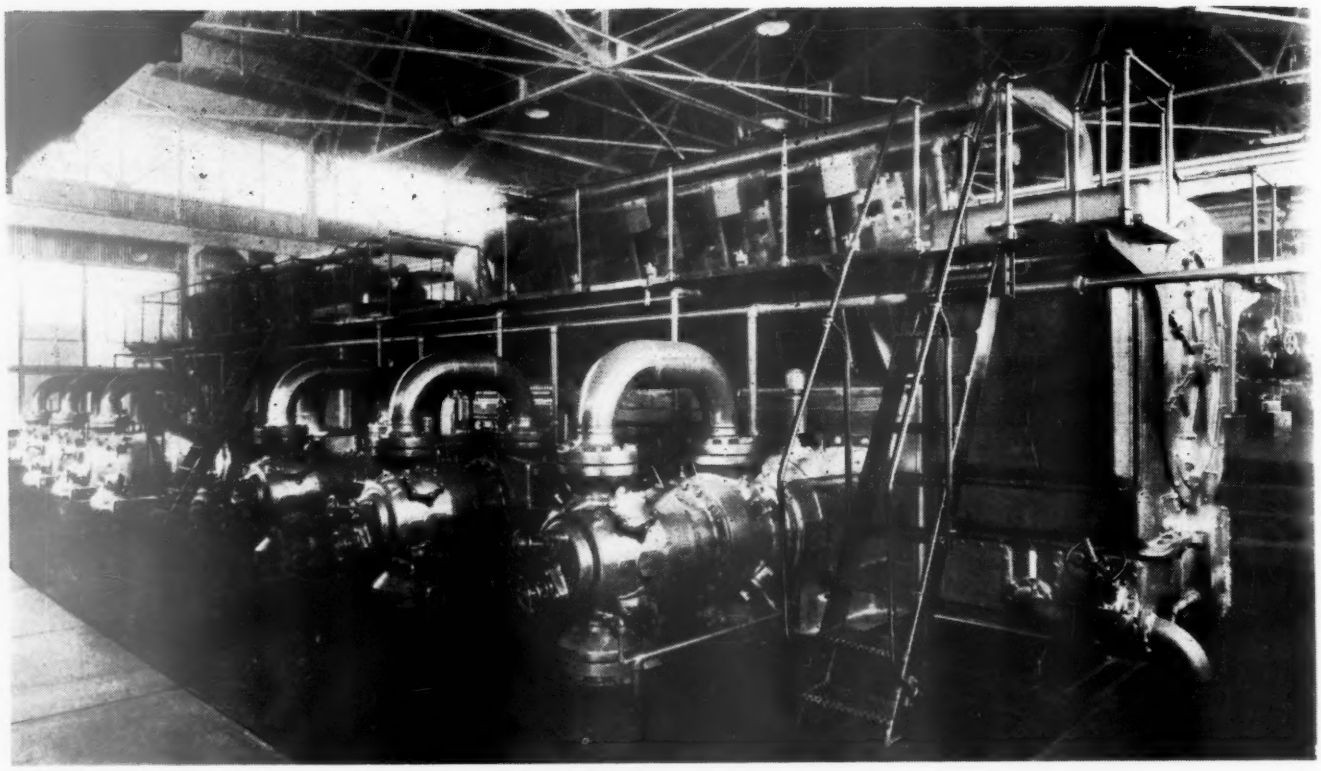


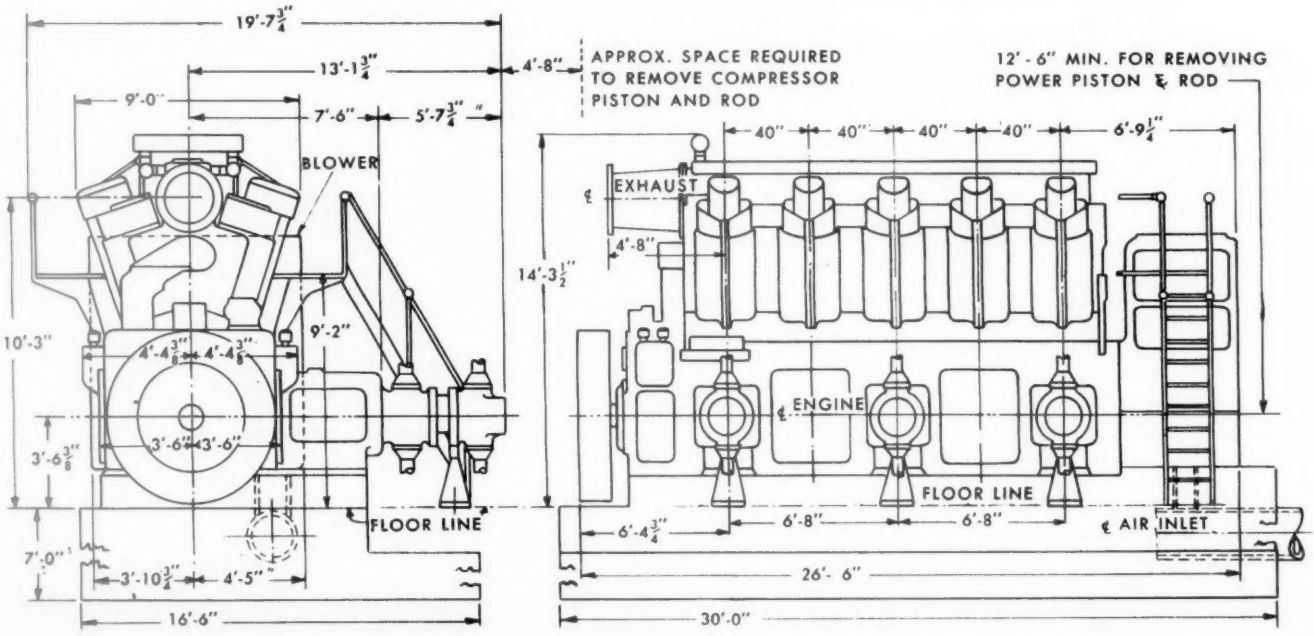
FIG. 7. Two of four 2400-hp GMW compressors installed in a large Kansas pipe line station.

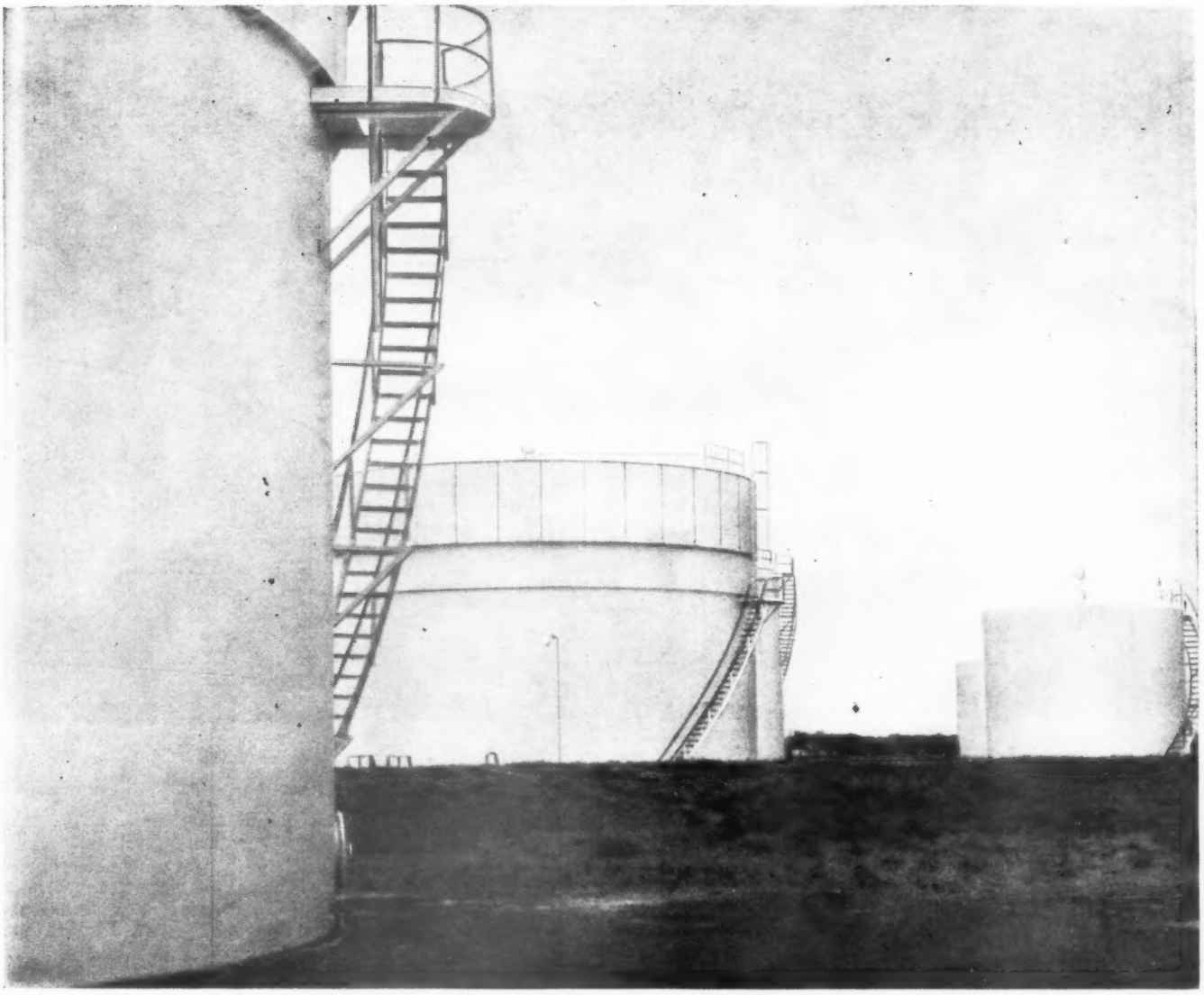
percentage of down time, as compared to the failure of the same part in the big, slow speed engine.

● **Labor cost.** The amount of labor required in a compressor station is apparently largely a matter of the number of units being operated, rather than the size of the individual units. For that reason, as well as first cost reasons, there should logically be a tendency toward larger enclosed, compact, one-piece compressor units. It takes considerably less labor to operate one 2400-hp angle machine than it does to operate one 1600-hp horizontal machine. The angle machine is fully enclosed with practically everything automatically lubricated and there isn't much the operator can do to the machine, except observe cooling water, oil, etc. With the horizontal engine there are innumerable spots that require constant attention. On the modern machine there is little climbing over the engine, because there isn't anything to do when the operator gets up there.

At first observation, labor may be inclined to resent compact, larger machines that obviously require larger attention; yet when they take time out to consider the overall picture they are

FIG. 8. Spaee plan drawing showing dimensions of 2400-hp. 2-cycle V-angle compressor unit.





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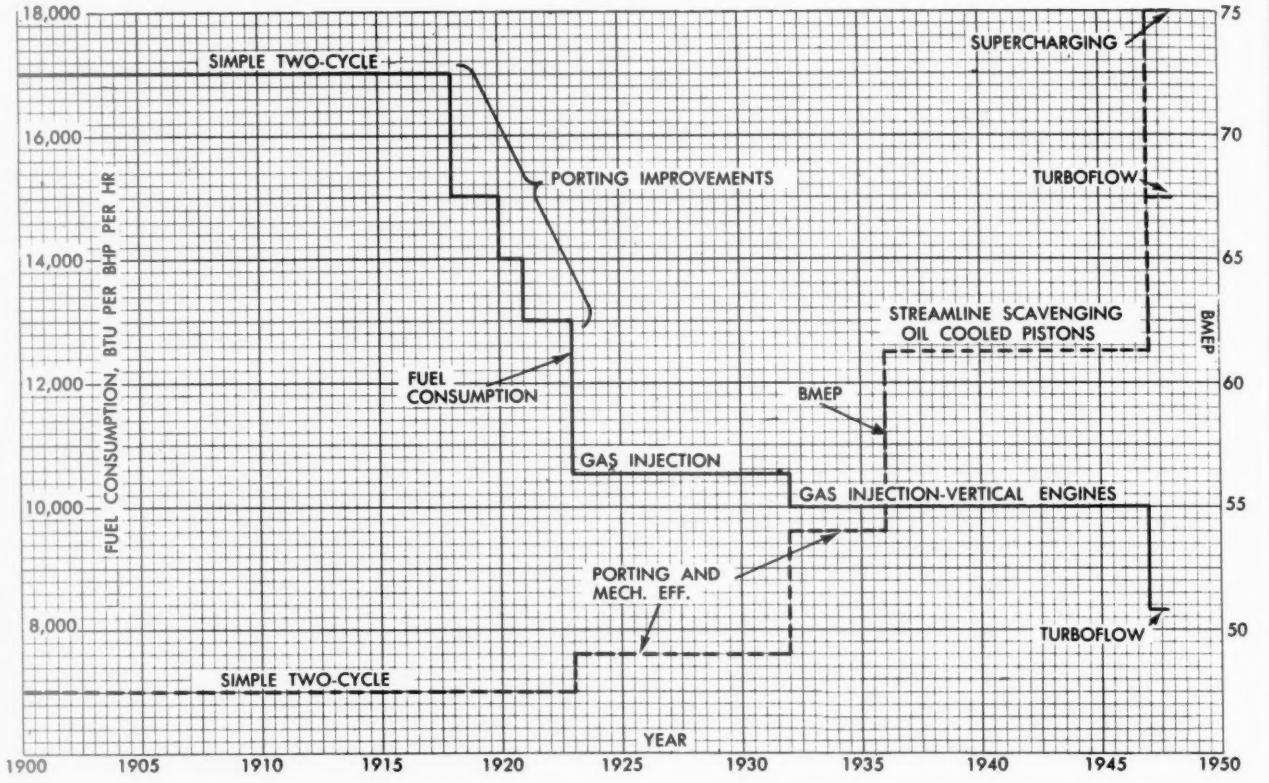


FIG. 9. Graphic presentation of history of improvement in rating and fuel consumption of two-cycle gas engines.

much better off. The operation of these modern machines is much less difficult for the men. In addition to that, we call attention to the fact that the history of so-called labor-saving machinery is that it makes jobs instead of eliminating them. The automotive industry is a perfect example of that, because there they go to the ultimate to put in labor-saving machinery. By the installation of this machinery and only by it has the cost of cars come down to a point where the public can afford them. By so doing, the volume of production has been increased so tremendously that the automotive industry is one of the largest employers of labor, whereas without labor-saving machinery it would be a small percentage of its present size.

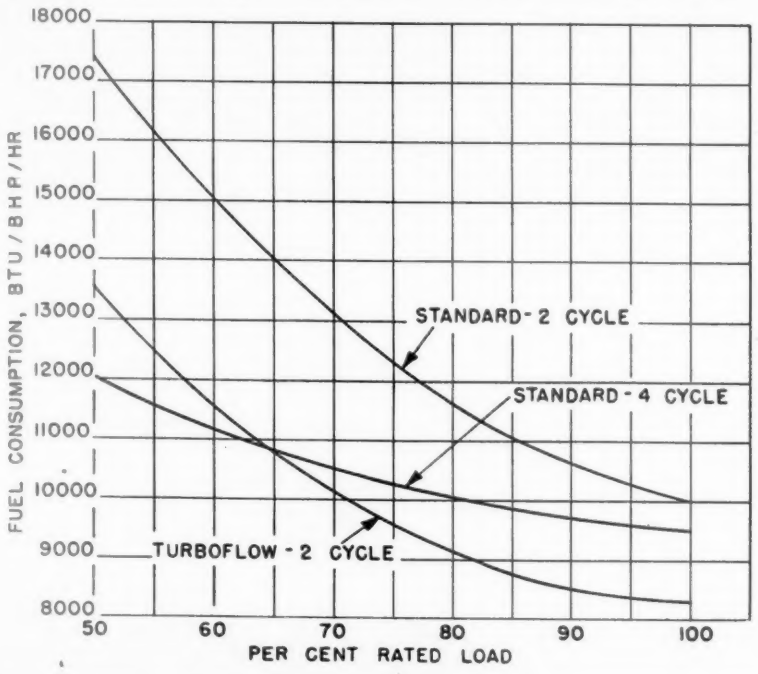
There is of course a possibility today of some types of compressors that employ still less labor than the most modern internal-combustion engine, but of course in that case the labor saving must be balanced against the increased power cost.

● **Noise.** Some of the earlier angle machines installed were notoriously noisy. Operators had been accustomed to the slow moving horizontal machinery with its comparative quietness and were disturbed by the general din in the compressor station employing angle machines. This has been largely conquered through the use of precision workmanship in the building of such machines, until today it can be truthfully stated that the largest angle machines are little if any more noisy than their horizontal competitors.

It is very difficult to present a report of progress on modern gas compressors without appearing to be prejudiced in favor of that type compared to horizontal engines. Actually there is no prejudice and our company remains in a position to serve its customers with either type of machinery. If there appears in this article to be any prejudice it is solely because the developments have been such in recent years that we truthfully do have now the angle type compressor available in a very attractive form.

★★★

FIG. 10. Fuel consumption comparison curves for various gas engines.



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MIDWEST WELDING FITTINGS IMPROVE DESIGN AND REDUCE PIPING COSTS

The aerial line walker is here on the last lap of his detail—taking a look at the lines coming into the terminal at Avila, California, from San Luis Obispo. He covers the entire pipe line system in two afternoons a week, and is ready for emergency runs at any time.

WALKING ON AIR

By RICHARD SNEDDON, *Pacific Coast Editor*

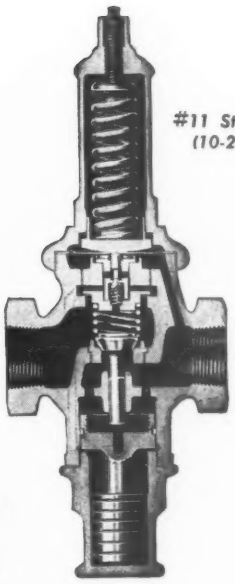
EXCLUSIVE

It is probable that no single entity in the entire roster of commercial enterprise is more conservation conscious than the petroleum industry. There are several reasons for this. For one thing, it might be pointed out that if, as the historians assert, the early stages of petroleum development were conducted more colorfully than conscientiously, we can say very definitely from our own experience that the past two and a half decades have been characterized by something altogether different—an operational meticulousness that permits of no chance taking, and certainly countenances no waste.

Over the years, the oil industry has become increasingly competitive, and in a keenly competitive system quite obviously anything that adds to production cost must, if at all possible, be eliminated. By the same token, the petroleum industry has become daily more scientific, and scientists, of course, are the natural enemies of waste. Finally, while harnessed petroleum is one of the world's greatest beneficences, the black fluid and many of its products are anything but friendly in the wrong environment, and particularly so when they fall into inexperienced hands. In consequence, there are endless agencies and devices by which present day operators seek to conserve the last vestige of their precious raw material, and simultaneously keep it out of those environments and hands, in which, lacking adequate control, it might become destructive of life and property.

Of all the conservationists who make up the personnel of the petroleum industry, none is more zealously devoted to the doctrine of thrift than the pipeliner. He guards the commodities that are temporarily in his keeping with every known precaution and device, and he strives without surcease not merely to *account for* them, but *to make eventual physical delivery* of the last fraction of a barrel to its ultimate destination. In this worthy objective he must battle constantly and vigorously against evaporation losses, line leakage, spillage, and wastage of many sorts. The record shows that he has been remarkably successful, but yesterday's success does not mean that he can relax today, for these thieving gremlins are always on the prowl, and the pipeliner is doomed to everlasting watchfulness.

As a part of this protective campaign,



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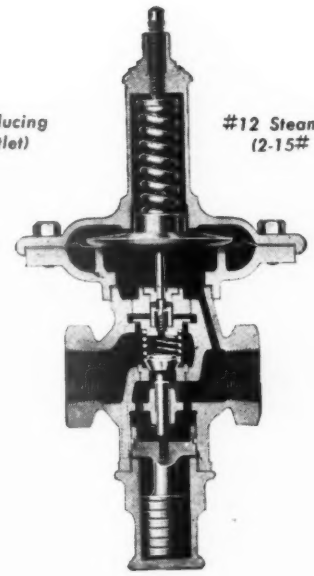

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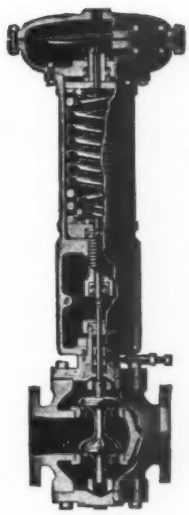

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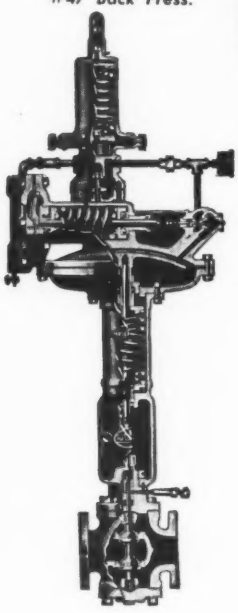

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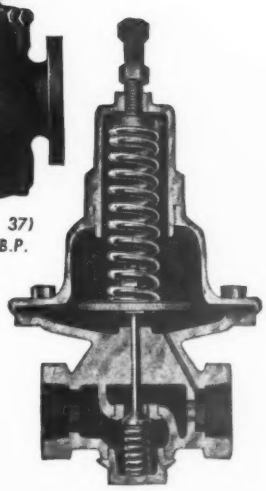

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EQUIPMENT WITH ENGINEERING SERVICE

MECO

The line walker of the horse and buggy era was a colorful character, whose horse, it is said, learned to stop at the smell of fresh crude oil. His technique was an improvement over actual walking but had still some drawbacks. This, of course, refers to the technique of the line walker, not that of the horse.

Privilege of riding was partly offset by the fact that with a horse and buggy at his disposal the line walker could now carry a pick and shovel and other useful accessories. Nor did he lack for an opportunity to use his tools. He is seen here digging a bell hole preparatory to attaching a saddle to a leak.

and almost coincident with the construction of the first oil pipe line, there came into being an interesting sort of specialist, known as a line walker. His function was very simple—to traverse the course of the pipe line and report promptly any and all leaks. This job had the immediate effect of virtually taking a man out of circulation, for thereafter he became a mere voice, flitting from one isolated telephone booth to another, and announcing to the dispatcher that everything was all right or that there was a line leak of such and such dimensions at some particular place. His territory seemed to be the wide world, and for a man afoot, his task seemed to be endless. Naturally, of course, in a large organization, several walkers would be required to cover all sections of all lines, and we have known conditions, especially in mountainous terrain, under which it took the line walker several days to cover a comparatively short section of line. At best, the progress of the line walker was slow, and while he was a good instrument in his day, he was soon outmoded as an "all-purpose" device, for there were many places he could not go, and the human machine had other quite definite limitations.

When the inadequacy of "shank's mare" was realized, the walker was provided with a real horse—and buggy, and thence was initiated for him a season of slightly more comfortable existence. However, when the superintendent became so considerate as to provide him with a buggy in which to ride, he also was so inconsiderate as to provide a pick and shovel and a couple of saddles, so that now when possible and expedient, he was expected in the case of small leaks to dig a bell hole, attach a saddle to the line, or at least make temporary repairs to hold the leak at a minimum until the pipe line gang came along to do a more permanent job. This was a distinct advance in technique, but still had some drawbacks—there were lots of spots inaccessible by horse and buggy, and besides a horse is no more invulnerable to fatigue than is a man. Also, it may be remarked that after an arduous day of bumping over faintly etched trails and unfriendly terrain, the prospect of having to currycomb a horse and put it to bed before he could climb into his own, was never too pleasing to the line walker. Amazing tales are told of the sagacity of some of the old steeds that hauled the line inspectors over their tortuous routes. One pioneer pipeliner swears, and gets pretty mad if you doubt him, that the more intelligent horses automatically stopped at the smell of fresh crude, so the walker didn't need to be quite so alert as one might suppose.

It may be assumed, incidentally, that leaks were much more plentiful in the early days of pipelining than they are today, for the joining of pipe has with everything else shown a continuous improvement down through the years. In the beginning, pipe was completely unstandardized, and lengths were connected in a variety of ways, producing tightness in a variety of degrees in the finished joints. Threaded joints were first screwed together with hand tools, then came the makeup machine, instituting some improvement, but still leaving something to be desired. On lines carrying high pressure, threaded joints were distinctly vulnerable, and collar leaks were more common than the pipeliners cared to have them. Other influences, such as corrosion and electrolysis, contributed their share to the discomfort of the operators, and kept periodic line inspection a prime necessity. The greatest single preventive of line leakage since the birth of the transportation industry is the welded line. This, together with the development of seamless pipe, has made life a little more pleasant for the pipeliner and the line walker by reducing leakage to a very scant minimum.

Returning to the evolution of the line walker, however, the horse and buggy stage of his growth was followed by the auto era, when he went forth resplendent in a pickup truck in which he could much expedite his assignment, and so devote some of his time to other essentials. He could, for instance, not only carry all the tools and equipment he needed for spot repairs, but could transport supplies to district offices, and even deliver mail to employes in outlying areas. He became more generally useful in new ways but at the same time, his pickup truck could only go where there was some semblance of a road, so there were limitations here too, and although the line walker was gradually acquiring greater speed in the performance of his work, he was still decidedly restricted in the scope of his operations.

In the past few years, we have witnessed the greatest change in line walking technique since the process was first instituted, and one that appears to offer a solution for most of the shortcomings of prior methods. It might be termed

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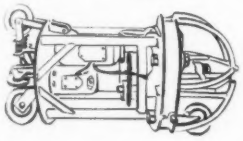

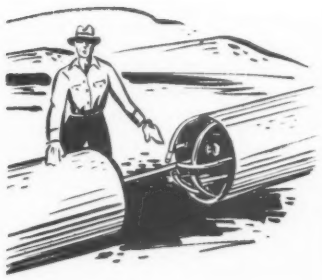

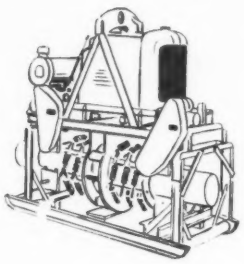

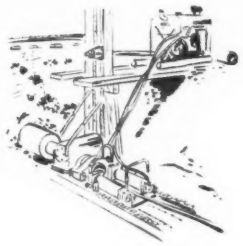

INSIDE LINE-UP CLAMPS
•
CLEANING AND PRIMING MACHINES
•
STATIONARY COATING AND WRAPPING MACHINES
•
EXPANDERS
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INSULATED TAR KETTLE WITH AGITATOR
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ROAD BORING MACHINES
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- **SAVES TIME**
- **SAVES MONEY**
- **SAVES FINGERS**
- **SAVES PISTON RINGS**
- **SAVES TEMPERS**

Pictured above is a STANDARD X-PANO being used to expand an 18" ring over an 18" diameter piston.

Use Standard X-PANO for 12 to 24-inch diameter rings; Junior X-PANO for 7 to 11-inch diameters. Three different jaw widths. Made of durable aluminum alloys throughout, X-PANO's special ratchet feature permits holding the ring in any expanded position desired.

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PIPE
COATING — WRAPPING
CORPUS CHRISTI — REFUGIO

Returning from a close inspection of the marine loading lines at Avila, California. The pilot has a waiver that permits him to travel at low levels outside of the town areas. He appears to care little what terrain he covers, maneuvering easily in mountains and valleys and often dropping to a 40-ft altitude for inspection. He covers the system more quickly and more completely than has been possible by any prior method.

Robert M. Smoot of Petroline Air Survey is one of the pioneers of pipe line inspection by air. Long experience in reconnaissance flying has given him a rare eye for detecting unusual markings. Pipe line leaks are a cinch to him—he even picks up crankcase drainings when they lie on the route he flies.

"aerial line walking," for it is just exactly that, and not only has it enabled the pipe line department to cover all its lines in a mere fraction of the time formerly taken, but no part of the line is beyond the observation of the flying inspector. It doesn't matter whether it is strung over the mountains or laid on pilings that reach out into the sea, he takes it all in stride, and the dexterity with which he maneuvers his plane to get down into narrow dips and gullies for a close enough look, is a treat to see.

It was our privilege recently to watch Bob Smoot of the Petroline Air Survey, doing his stint over Union Oil Company of California's lines up in the northern district, and we were amazed at the facility and speed with which he twists and turns as he follows the pipe lines almost at ground level. He uses a Piper Cub airplane, and seems to be able to make it do at a 40-ft altitude all the stunts that the Three Musketeers used to perform at 5000 ft. And he has an eye that is so well trained in picking up oil leaks that it could probably pick up a crude stain on the pants of a pumper. Skeptics have been trying to discount this ability ever since he started his industrial adventure, but he has spotted without fail artfully concealed seepages, and has even on occasion reported indications so small that upon investigation they turned out to be crankcase drainings.

Smoot spends two days a week on Union's northern lines and covers them completely. In his work, he uses no surveying instruments of any kind. Through years of experience in reconnaissance flying he has acquired an unusual aptitude for noting strange markings and ground effects, and he has a waiver that permits him to fly low outside of the town areas. This he does—at virtual ground level—and there is little that escapes his discerning eye along the route. When he sees a crude oil spot or other indication of a leak, he marks the exact place and then notes the character of the leak and its location on a piece of paper. This he puts into a metal tube, which he drops to the operator at the nearest pump station. The operator then reports known details to the dispatcher, and a crew or a man, as the occasion may require, is sent out to make the necessary repairs.

A factor that is much in favor of the aerial line walker is that he can cover practically every inch of the line. There are sections of line that cannot be surveyed by the driver of a buggy or an automobile, unless he abandons the vehicle and takes to his feet, but there is none of the line area that is beyond the vision of the flyer—of this particular flyer, at least. He flies over the most rugged mountain terrain, hugging the surface at seemingly impossible levels, and then skims out on the ocean, a few feet above the piling, to check up on marine lines. In a comparatively short time he has become familiar with every kink and bend on the entire pipe line systems with which he is concerned, and when the line suddenly veers off at an acute angle, he flits around like a swallow and takes the new direction as expertly as if he were radio controlled.

It is of considerable advantage to the pipe line department that when a leak is suspected, the flyer can go out to the most likely areas, make a check, and report back in the briefest possible time. As a matter of fact, the whole process has so many advantages and so few disadvantages that for lines of any substantial length, it seems to answer the line surveying problem better than anything that has yet been tried. It accomplishes with a speed so far unknown, a more complete and more effective routine inspection than any of the prior methods, and because it is still comparatively young, it may be confidently assumed that the future will see the adoption of instruments and techniques that will render it still more effective. In the meantime, it is safe to say that although we may look forward to technological advances in the process, it will be a long time before we are likely to see any improvement in stick handling, for Robert M. Smoot pilots as if he were built into the ship, and enjoys every minute of it. ★ ★ ★

PRECISION ...the key to efficient valve performance

Needless to say, a valve must operate with precision to perform efficiently in actual service. But to make this possible there must be precision in everything that goes before—precision in design, in selection of materials, and in finishing to exact specifications.

Throughout more than a century of making valves—and valves only—"precision" has been the watchword at Powell. That is why today, in every branch of industry, Powell Valves are noted for efficiency under any and all service conditions.

And don't forget that Powell Engineers are always glad to help you select the precise valves to meet your individual flow control requirements.

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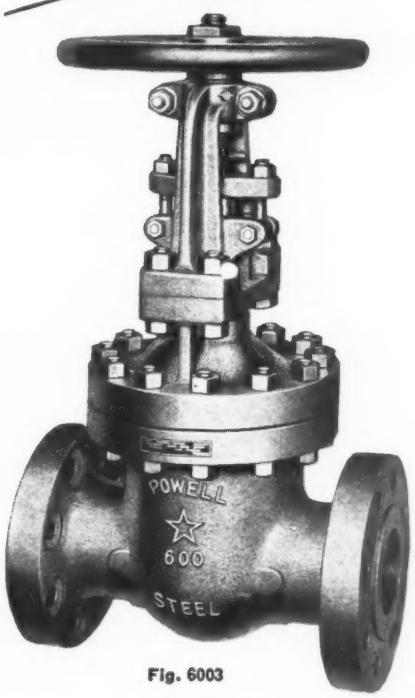


Fig. 6003

Fig. 6003—Class 600-pound Cast Steel Gate Valve with flanged ends, bolted flanged yoke, outside screw rising stem and taper wedge solid disc.

Fig. 1793—Large 125-pound Iron Body Bronze Mounted Gate Valve. Made in sizes 2" to 30", inclusive. Has outside screw rising stem, bolted flanged yoke and taper wedge solid disc. Also available in All Iron for process lines.

Fig. 3061—Class 300-pound Cast Steel Swing Check Valve with flanged ends and bolted cap. Disc has ample lift to permit full, straightway, unobstructed flow through valve body.

Fig. 3003—Class 300-pound Cast Steel Gate Valve with flanged ends, bolted flanged yoke, outside screw rising stem and taper wedge solid disc.

Fig. 1793

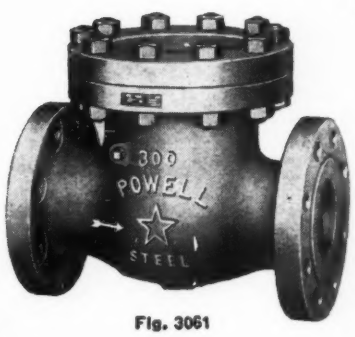


Fig. 3061

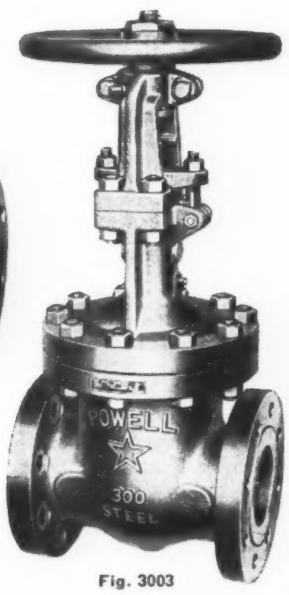
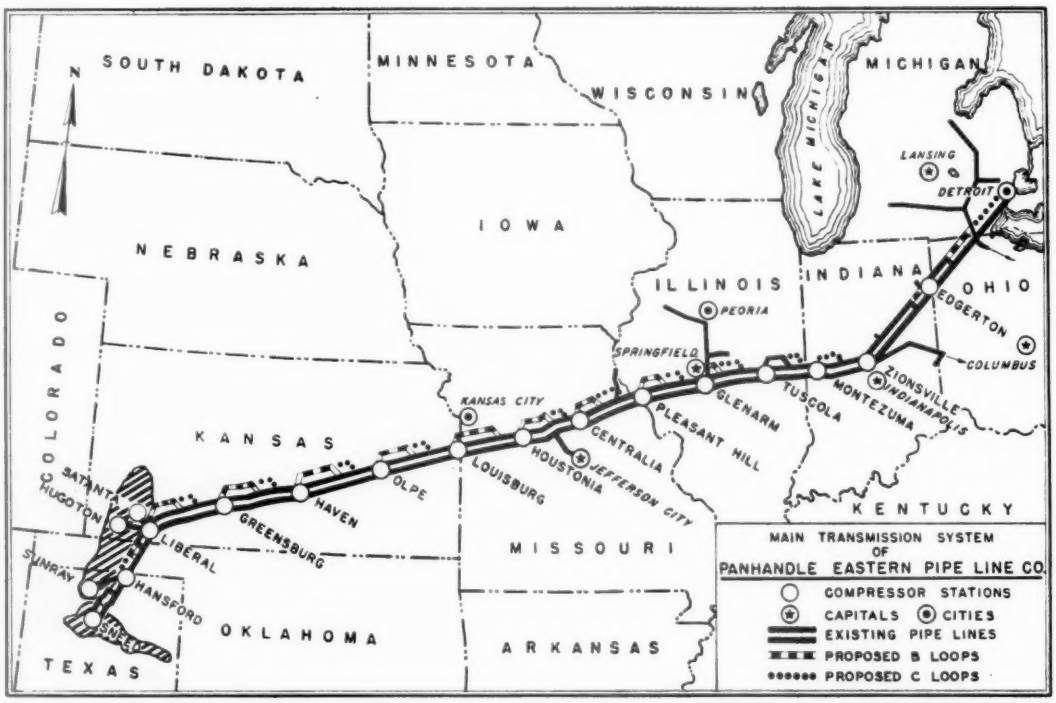


Fig. 3003

POWELL VALVES



Panhandle Eastern's 1947 expansion program

By C. H. M. BURNHAM, *Chief Engineer*, Panhandle Eastern Pipe Line Company

To meet the increased demands for natural gas in the markets that it serves, Panhandle Eastern Pipe Line Company built, in 1947, gas transmission facilities consisting of extensive changes and additions to 15 of its existing compressor stations, and one new field gathering station.

EXCLUSIVE

The new station was constructed in Haskell County, Kansas, near the town of Satanta. The equipment installed at this station consists of three 800-hp Clark Brothers compressor units. An innovation at this station is the method by which auxiliary power was eliminated. This was done by connecting to each engine two vertical centrifugal pumps mounted below the floor and driven through a single shaft. Thus each of the compressor units pumps its own cooling water requirements.

At Satanta station, locally produced natural gas, after having been dehydrated, is compressed and discharged into the line leading to the Liberal compressor station, situated on the main transmission system approximately 25 miles to the southeast.

At Liberal station the compressor power was increased by the addition of four 2400-hp Cooper-Bessemer vertical engines installed in a two-bay extension of the existing main building. Prior to 1947's addition, this station consisted of eleven 1000-hp horizontal gas-engine-driven compressors, each occupying a 28-ft bay in a building 68 ft wide and more than 300 ft long. The adding of the four 2400-hp vertical engines thus almost doubled the power in this station, but required, however, only a 56-ft addition to the building.

Southwest of Liberal, Kansas, the company's Sunray and Hansford compressor stations each received an additional unit; Sunray, a 1000-hp Cooper-Bessemer vertical compressor, and Hansford, an 800-hp Ingersoll-Rand unit.

East of Liberal station the 1947 program involved the installation of four 1600-hp Clark Brothers vertical compressor units at Greensburg, Haven, Olpe, and Montezuma compressor stations, respectively. Here again each of these main units drives its own recirculating water pump through a gearhead with a shaft extending through the floor.

At Louisburg station a 1000-hp Cooper-Bessemer vertical engine was added, and Pleasant Hill and Centralia station each received an addition consisting of a 2400-hp vertical engine of the same make.

To carry out the 1947 program Panhandle Eastern Pipe Line Company employed the services of the following five construction firms:

1. The Fluor Corporation, Ltd., Los Angeles, California, which built the additions to Liberal and Hansford stations.
2. Fulton Engineering Company, Lubbock, Texas, which built Satanta station.
3. The Dresser Engineering Company, Tulsa, Oklahoma, which built the additions to Greensburg, Haven, and Olpe stations.
4. The Fish Engineering Company, Houston, Texas, which built the additions to Louisburg, Houstonia, Centralia, and Pleasant Hill stations.
5. The Graver Tank and Manufacturing Company, Chicago, Illinois, which not only built the addition to Montezuma station, but made extensive piping changes at Glenarm, Tuscola, Zionsville, and Edgerton stations.

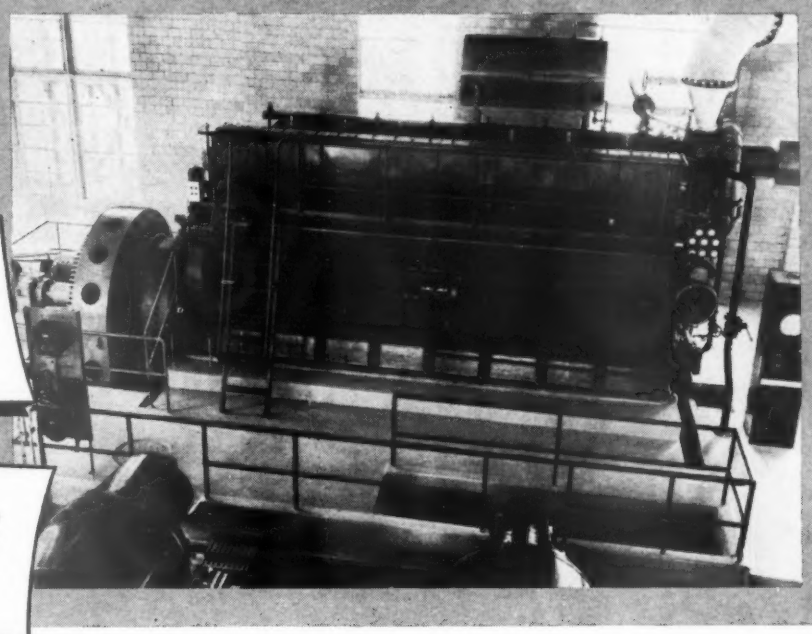
Piping changes, for the purpose of accommodating higher working pressures, were made also at all other stations from Liberal eastward, in conjunction with the various additions.

Failure to receive the necessary 26-in. OD pipe resulted in no main line loops being built in 1947. This program of main line construction, shown as "B" loops on the accompanying map, is scheduled to begin in 1948, and upon its conclusion will be further expanded by additional facilities known as the "C" facilities, application for a certificate of convenience and necessity covering which was filed March 5, 1947, with the Federal Power Commission.

This most recent application contemplates the construction of approximately 355 miles of additional pipe line loops, and the installation in existing stations of compressor units totaling at least 31,600 hp. ★ ★ ★

OVER 36% Thermal Efficiency!*

In the FIRST Supercharged Dual Fuel Diesel to Demonstrate All Its Guarantees



* Developed by this Worthington Supercharged Dual Fuel Diesel Engine, Type SEHGO-8, on acceptance test at the municipal plant, Lamar, Colorado.

* TEST DETAILS: 7050 net Btu per brake horsepower-hour at full load . . . total gas and pilot oil fuels included . . . elevation 3600 ft.

First in the U. S. to produce a 4-cycle Dual Fuel Diesel . . . first in the world to supercharge this type of engine . . . Worthington offers the Lamar data as proof of *thinking ahead* in Diesel engineering. But such records are only part of the Worthington economy story. Today, with a scarcity of all fuels in prospect, you can save by

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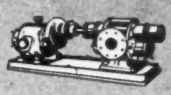
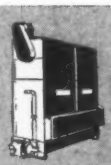
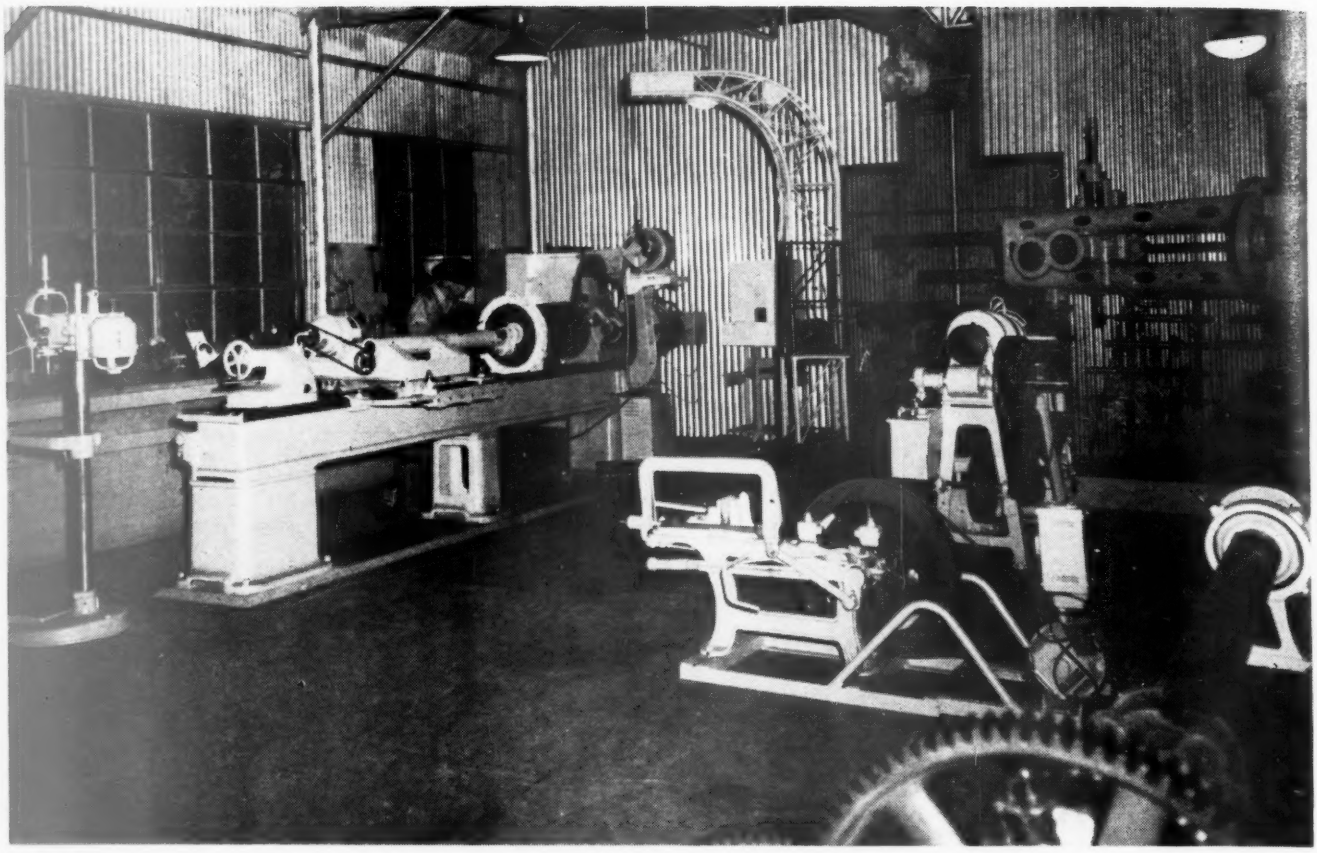


Oil Transfer Pumps

Cooling Water Circulating Pumps



Evaporative Type Engine Water Cooler



View of machine shop showing at left a 10-in. precision drill press and lathe with cylinder guiding machine in place, preparatory to grinding the cylinder. At rear center is a portable floor crane and power-driven pipe threading machine. In the foreground is a power hack saw; at right rear is a 5-ft radial drill, and at right foreground is a 4½-in. by 10-ft horizontal boring bar.

Modern machine shop speeds repairs

By W. E. NESTOR, *Superintendent of Compressor Stations*, Arkansas Louisiana Gas Company

EXCLUSIVE

DURING the early spring of 1947 it became apparent that in order to handle the extensive repair work for our various compressor stations a more modern machine shop at the Rogers compressor station of the Arkansas Louisiana Gas Company would greatly facilitate the machining of engine and compressor parts during the regular summer repair period.

Plans were therefore drawn up by our compressor station department engineers for a 30-ft by 60-ft fireproof building, of steel frame construction with corrugated sheet covering.

Due to the shortage of structural steel it was decided to fabricate the framework of used pipe by electric welding.

Through our purchasing department the necessary quantity of 4-in. used pipe for columns and a string of 2-in. corkscrewed well tubing was obtained and hauled to the site where the tubing was straightened in a 40-ton hydraulic press used at the old shop for removing and installing bushings.

Columns and trusses were fabricated on the ground and raised into place by a portable drilling mast used by our production department to drill water wells.

All columns are 4 in. by 12 ft with welded base plate and are bolted to building foundation piers. Trusses, purlines, and girts are of 2-in. tubular construction. The entire framework is electric welded throughout and roof trusses are designed to carry the load of our heaviest repair parts on the overhead crane block runway that extends the entire length of the building.

Machine tools in the shop are all driven by individual motors and consist of a 20-in. by 18-ft engine lathe, a 5-ft Universal radial drill, a 20-in. sliding head drill press, a 10-in. precision drill press, high speed tool grinder, power hack saw, 40-ton hydraulic press, and power pipe threading machine.

There is also a 4½-in. by 10-ft portable boring bar permanently mounted on a base plate for boring large cylinders. This bar can be dismantled and transported to any of our stations to rebore cylinders without removing them from the engine or compressor mounting.

A crank pin power driven turning machine is part of the shop equipment, and this, too, being portable can be transported to wherever it may be needed for truing up worn crank pins. It has a capacity for handling up to 11-in. diam crank pins.

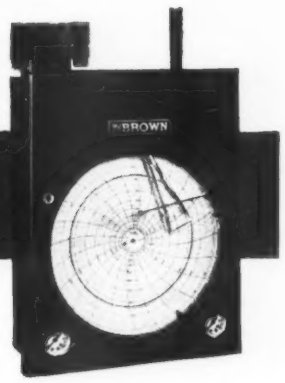
Several special tools to facilitate repair work were designed by our compressor station department engineers and built in our new shop. One of these is a precision cylinder grinding machine, which is mounted on the lathe carriage

Compare *performance* features

FLOW METER DATA

FACTOR (*See Notes*)	BROWN METER	METER NO. 2	METER NO. 3	METER NO. 4	METER NO. 5
1—Calibration Error					
Average Upscale	0.15%	0.48%	0.41%	0.22%	0.15%
Average Downscale	0.16%	0.58%	0.49%	0.19%	0.50%
Maximum	0.50%	1.10%	1.43%	0.40%	0.80%
Minimum	0.00%	0.00%	0.00%	0.00%	0.00%
2—Readability	A	B	B	B	B
3—Sensitivity	0.10%	0.12%	0.12%	0.12%	0.10%
4—Dead Zone	0.23%	0.25%	0.23%	0.23%	0.70%
5—Response Speed	22 secs		42 secs	32 secs	37 secs
Overload Seal	B	C	B	B	A
Adjustments					
Zero	A	C	B	C	B
Pulsation	A	C	C	C	B

A = Superior B = Satisfactory C = Inferior



Consider the results of this comparative *performance* test conducted by Brown engineers.

The test sought the answer to the all-important questions: In the final analysis, what is the flow meter's ultimate installed performance? How easy is the meter to operate and maintain at top performance?

Every effort was made to be unbiased. Regular production models were used, from the Brown plant as well as from competitors. Each meter was carefully adjusted for best performance. On competitive meters, if the "as received" calibration was poor, the instrument was recalibrated to obtain minimum error.

The figures speak for us. Brown more consistently ranks "tops" in performance features. Let us prove it in your plant under your operating conditions.

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NOTES

All percentages are based on per cent of full scale differential pressure.

1. **Calibration Error:** Difference between instrument readings and an accurate standard water column.
2. **Readability:** A function of length of arc for full scale pen travel and of number and fineness of chart graduations.
3. **Sensitivity:** Minimum change in the differential pressure required to cause motion of pen.
4. **Dead Zone:** Zone in which differential pressure can be varied, from a set point, both up and downscale, without causing pen motion.
5. **Response Speed:** Time required for instrument to record an instantaneous 100% change in differential pressure.

BROWN *Advanced Instrumentation* FOR BETTER PROCESSING

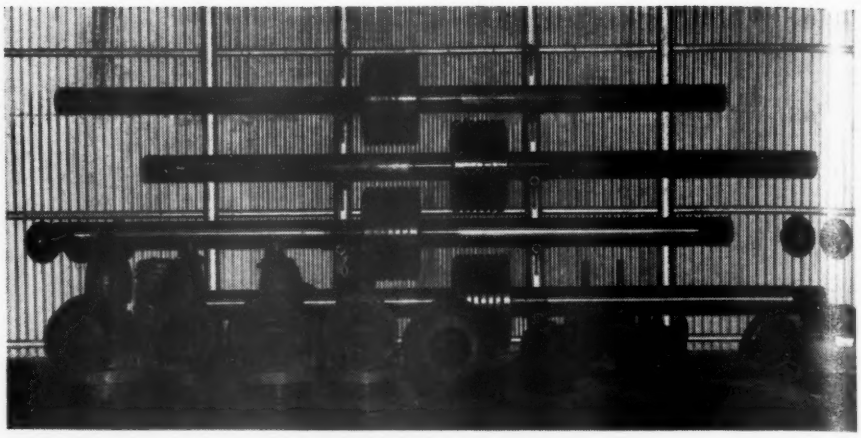
Product of MINNEAPOLIS Honeywell

and capable of precision grinding cylinders up to 12 in. diam and 36 in. long.

Another is a hand operated floor crane for lifting heavy engine parts from shop floor to the machine tools. It has a capacity of 3000 lb.

A milling attachment for the engine lathe is a part of the shop equipment and enables the operator to perform many operations, such as milling keyways in shafting and bushings, milling teeth in gears, and many other jobs that otherwise would require the use of an expensive milling machine.

Such replacement parts as crank pin boxes, wrist pin boxes, wrist pins, exhaust valve guides, exhaust valve and inlet valve seats, compressor suction and discharge valves, cylinders and pistons for our auxiliary engines and other replacement parts are made entirely from forgings and castings obtained locally, effecting a considerable saving in maintenance cost and delays in shipment.



One bay of the building is used to store spare engine parts. This is a rack for pistons. They can be picked up easily by a chain block on an overhead trolley.

Ample daylight lighting is provided by large steel sash ventilator type windows in continuous rows on each side of the building. Night lighting is effected by the installation of twelve 200-watt overhead reflector lights, with individual lights at each of the larger machine tools.

Compressed air piping is installed throughout the shop with convenient outlets for operating air driven tools for chipping, drilling, reaming, etc.

Focal color painting of all machine tools serves as a safety measure, as well as relieving eye strain and fatigue of operators.

Electric power and lighting facilities were designed by and installed under the supervision of P. J. Chandler, assistant superintendent of compressor stations.

Building and special machine tools were designed by and built under the supervision of G. D. Green, assistant superintendent of compressor stations.

Photographs illustrating this article are by J. E. Hampson, Arkansas Louisiana Gas Company photographer. ★ ★

☆ ☆ ☆

There are more than 3600 oil and gas fields in the United States, embracing 846 counties in 26 states, according to *The Petroleum Data Book*. These oil and gas fields contain a total of more than 484,430 producing wells. The average daily production of oil wells in 1946 was 11.2 bbl.; the average for gas wells was 265,000 cu ft. U. S. oil and gas fields cover a total area of about 7,900,000 acres. Lands under lease by oil and gas operators in the United States are conservatively estimated at more than 125,000,000 acres and most of this vast area is being explored for oil and gas.

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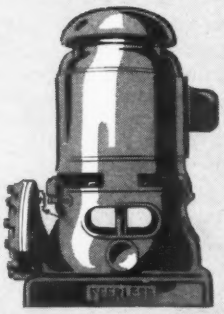

HORIZONTALS

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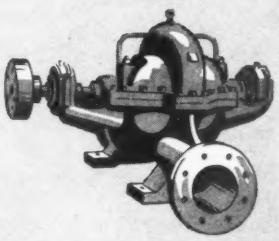

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Vapor output to heat input ratio for petroleum storage tanks exposed to fire*

By M. L. ARNOLD and G. H. HORNE

If a storage tank is exposed to fire, its contents will be made to boil. Provision must be made to release the vapors. If the tank venting equipment is not large enough, the tank may be damaged and an already hazardous condition may thus be made more critical.

In this paper, generalized factors are derived for selecting the tank vents or relief valves. The procedure will be useful for two reasons: (1) Tedious computations are bypassed, and (2) the venting requirement for contents of various compositions may be readily visualized. Both pressure and atmospheric storage tank venting are considered.

The procedure for selecting tank vents sounds quite straightforward. You estimate the total heat-input rate to the tank from the surrounding fire. Then you look up the latent heat of vaporization for the material in the tank. Heat-input rate divided by latent heat gives the rate at which the contents of the tank are vaporized. Then, knowing the vapor rate and its temperature, a valve can be selected to protect the tank at any desired pressure.

The first step—the estimation of the heat-input rate—may be but little better than an educated guess. A few recommendations have been published.[1,2,3,4] It is beyond the intended scope of this paper to do other than cite these references.

After you have decided upon a heat-input rate, the methods proposed in this paper will make the selection of venting equipment for petroleum products as simple and direct as possible. We start with a unit heat-input rate—1,000,000 Btu per hr. For low pressure tanks, we show factors giving the air-equivalent venting rate. For high pressure tanks, the factors give directly the relief valve nozzle area. These factors are special groupings of physical or thermodynamic properties. They do the work—once and for all—of combining heats of vaporization, density, vapor pressure, etc., to obtain vent sizing data.

Our starting point in this work was a reference to such a factor in the NFPA Handbook of Fire Protection[4]. They refer to a typical straightrun gasoline from Mid-Continent crude oil. "From the analysis of the distillation characteristics of the typical gasoline, the maximum rate of vaporization, expressed in terms of cubic feet per hour, was found to be numerically equivalent to one-sixtieth of the heat-absorption rate expressed in Btu per hour per sq ft of cylindrical tank surface. They used a vapor specific gravity of 2.5. For our unit heat-input rate of 1,000,000 Btu per hr, this gives an air-equivalent venting rate of:

$$1{,}000{,}000 \times \frac{1}{60} \times \sqrt{2.5} =$$

26,300 cu ft per hr

This is approximate, since the correction for vapor temperature was not made.

We desired first to examine the derivation of this factor, and then in the course of so doing, to obtain similar factors for other materials and pressures. Finally, the results should be expressed in terms convenient for valve sizing. Vents for atmospheric tanks are rated by their manufacturers in terms of the number of cubic feet of air they will pass per hour at various pressures. For this reason, we have expressed the venting capacity required for low pressure tanks in terms of air-equivalent venting rate.

● **Derivation for atmospheric storage tanks.**

Given: A low pressure petroleum storage tank, within which its liquid contents are being boiled. The heat-input rate is arbitrarily selected.

Find: The air-equivalent venting rate, i.e., the rate of air flow measured at standard conditions, which when flowing through a given orifice at 60 F will cause the same pressure drop as would the vapors actually flowing from the tank.

$$Q = \frac{H}{L}(V_G - V_L)\frac{P_G}{P_S}\sqrt{\frac{Z_A T_S M_G}{Z_G T_G M_A}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Where:

- Q = air rate equivalent to the vapor rate leaving the tank, cu ft/hr,
- H = heat-input rate, Btu/hr,
- L = latent heat of vaporization at atmospheric pressure, Btu/lb,
- V = specific volume, cu ft/lb,
- P = pressure, psia,
- Z = perfect gas deviation factor,
- T = temperature, R = F + 460,
- M = molecular weight.

Subscript:

- G refers to the vapors in the tank,
- L refers to the liquid in the tank,
- S refers to standard conditions,
- A refers to air.

Where no subscript appears, reference is made to the vapors in the tank.

In equation (1), the ratio H/L gives the weight rate at which vaporization occurs. The term $(V_G - V_L)$ expresses the number of cubic feet of vapor leaving the tank per pound of material vaporized. The ratio P_G/P_S corrects this volume from tank pressure and temperature to standard conditions. The radical term can be considered as a correction factor to convert the volume rate of actual vapors to its equivalent rate of air flow.

Equation (1) expresses a heat balance to which factors have been applied to make the answer come out in the desired terms. It has been assumed that all heat is absorbed in the latent heat of vaporization; and none of the heat contributes toward superheating the vapors, or in chemical changes such as cracking. With this limitation, equation (1) is completely rigorous — but awkward to work with. Considering that we are dealing with low pressures, the following approximations can be made:

$$Z_A = Z_G = 1$$

$$V_G - V_L = V_G = \frac{RT_G}{M_G P_G}$$

The following numerical values are used:

$$T_S = 520 \text{ deg R}$$
$$P_S = 14.73 \text{ psia}$$
$$R = 10.71$$
$$M_A = 28.966$$

Substituting the foregoing into equation (1):

$$\frac{Q}{H} = 3.08 \times \frac{T}{LM}\sqrt{\frac{M}{T}} \quad . \quad . \quad (2)$$

The term Q/H is the ratio we desire to evaluate. It gives directly the air-equivalent venting rate per unit heat-input rate. The product LM is the molal heat of vaporization. The group T/LM will be recognized as the reciprocal of Trouton's ratio, LM/T. For many substances at their atmospheric boiling points, Trouton's ratio has a value of about 21. A more refined value of Trouton's ratio may be obtained from the Kistiakowsky equation (5):

$$\frac{LM}{T} = 7.59 + 4.571 \log T \quad . \quad (3)$$

This equation reflects the observed fact that the value of Trouton's ratio increases with the boiling point. It is in good agreement with data for a wide range of non-polar substances.

Equation (2) can now be written as:

$$\frac{Q}{H} = \frac{\sqrt{M/T}}{2.464 + 1.484 \log T} \quad . \quad . \quad (4)$$

*Presented before California Natural Gasoline Association, December 4, 1947.

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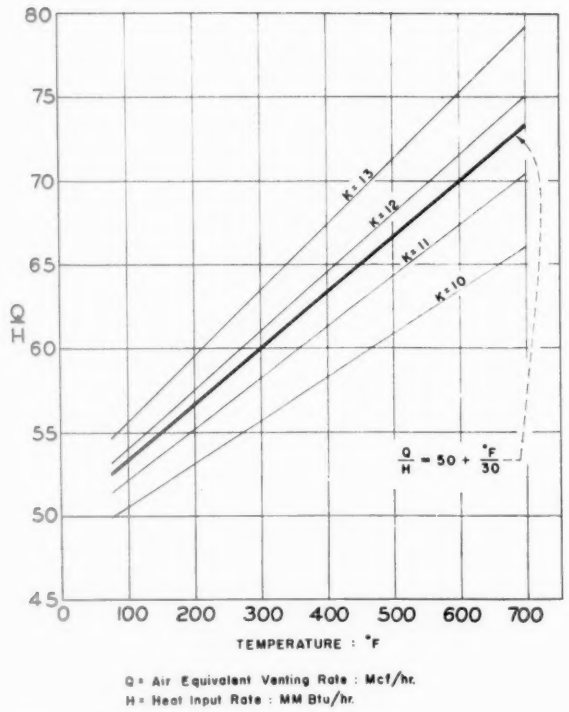


FIG. 1. Atmospheric storage venting.

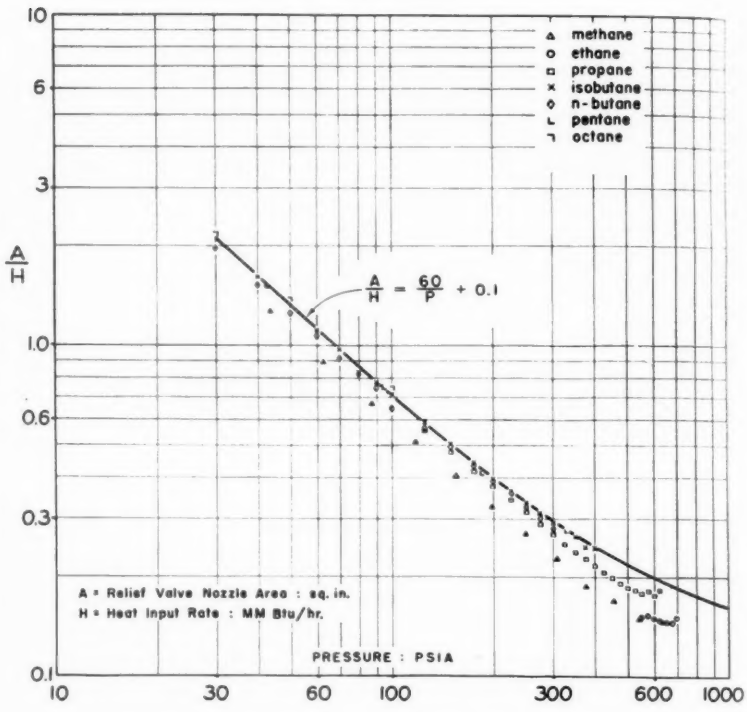


FIG. 2. Pressure storage venting.

Watson and Nelson[6] have correlated molecular weight and boiling point for petroleum hydrocarbons. They introduced a special modulus to characterize whether the material is paraffinic (high values of "K") or aromatic (low values of "K"). Using their correlation to eliminate molecular weight from equation (4), Fig. 1 was constructed. It shows the ratio Q/H as a function of temperature; i.e., the boiling point of the liquid, and of the Watson and Nelson characterization factor, K. An imperical line is shown that we propose for general use.

The equation for this imperical relationship is:

$$\frac{Q'}{H'} = 50 + \frac{t}{30} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Where:

Q' = air-equivalent venting rate, M cu ft/hr,

H' = heat-input rate, MM Btu/hr,

t = boiling point, F.

It is evident from equation (5) and Fig. 1 that values of Q/H increase with temperature. Then, other things being equal, a larger vent would be required for a high boiling material than for a low boiling material. This raises the question as to what temperature to use in the case of a mixture having a wide boiling range.

As the contents of a tank containing a wide boiling mixture are boiled away, two things happen: (1) The temperature increases and the "Q/H" ratio increases in accordance with equation (5); (2) the liquid contents of the tank decrease, thereby decreasing the area exposed to flame, and decreasing the heat-input rate to the tank. In general, the second of these effects will control. As boiling progresses, the liquid volume and total heat-input rate will decrease faster than the temperature "Q/H" ratio increase. The initial boiling point on the distillation curve should ordinarily be used for "t" in equation (5). An exception to this would be a high boiling material containing a small percentage of a low boiling fraction. The front of the distillation curve of such a blend would be abnormally steep. Another exception occurs in the case of large tanks if the formula used for heat-input rate considers only the surface up to a stated elevation above grade. Liquid in a tank above this elevation would have to be boiled off before any reduction in heat input were allowed. For example, if a tank can be filled to 40 ft, and if the walls of the tank only up to 30 ft were considered for heat input, then the 25 per cent point on the distillation curve should be used for "t" in equation (5).

If the tank is to operate under a slight pressure, say up to 15 psig, equation (5) can be used in the following manner. For "t" in equation (5), use the boiling point of the material at atmospheric pressure. This will introduce small errors into the values of "L," "V," and "T" of equation (1). The net error due to pressure can be corrected by increasing the value of "Q'/H'" obtained from equation (5) by 1¼ per cent for each pound per square inch pressure above atmospheric. For example, for a pressure of 10 psig, multiply equation 5 by 1.125.

● **Derivation for pressure storage.**

Given: A pressure-type petroleum storage vessel, within which its liquid contents are being boiled. The heat-input rate is arbitrarily selected.

Find: The relief valve nozzle area necessary to discharge the vapors.

The following is the formula for relief valve capactiy from the API-ASME Code for Unfired Pressure Vessels[7]. It has been modified by the inclusion of the perfect gas deviation factor:

$$W = 306\,AP\sqrt{\frac{M}{ZT}} \quad . \quad . \quad . \quad . \quad (6)$$

Where:

W = weight rate of flow through relief valve, lb/hr,

P = pressure at valve inlet, psia,

T = temperature at valve inlet, °R = °F 460,

M = molecular weight of vapors,

Z = perfect gas deviation factor at valve inlet,

A = relief valve nozzle area, sq in.

$$W = \left(\frac{H}{L}\right)\left(1 - \frac{V_L}{V_G}\right) \quad . \quad . \quad (7)$$

Where:

H = heat-input rate, Btu/hr.

L = latent heat of vaporization, Btu/lb,

V_G = specific volume of vapor in tank, cu ft/lb,

V_L = specific volume of liquid in tank, cu ft/lb.

The ratio H/L gives the weight rate at which boiling occurs. The term $(1 - V_L/V_G)$ is the fraction of total material vaporized which leaves the vessel.

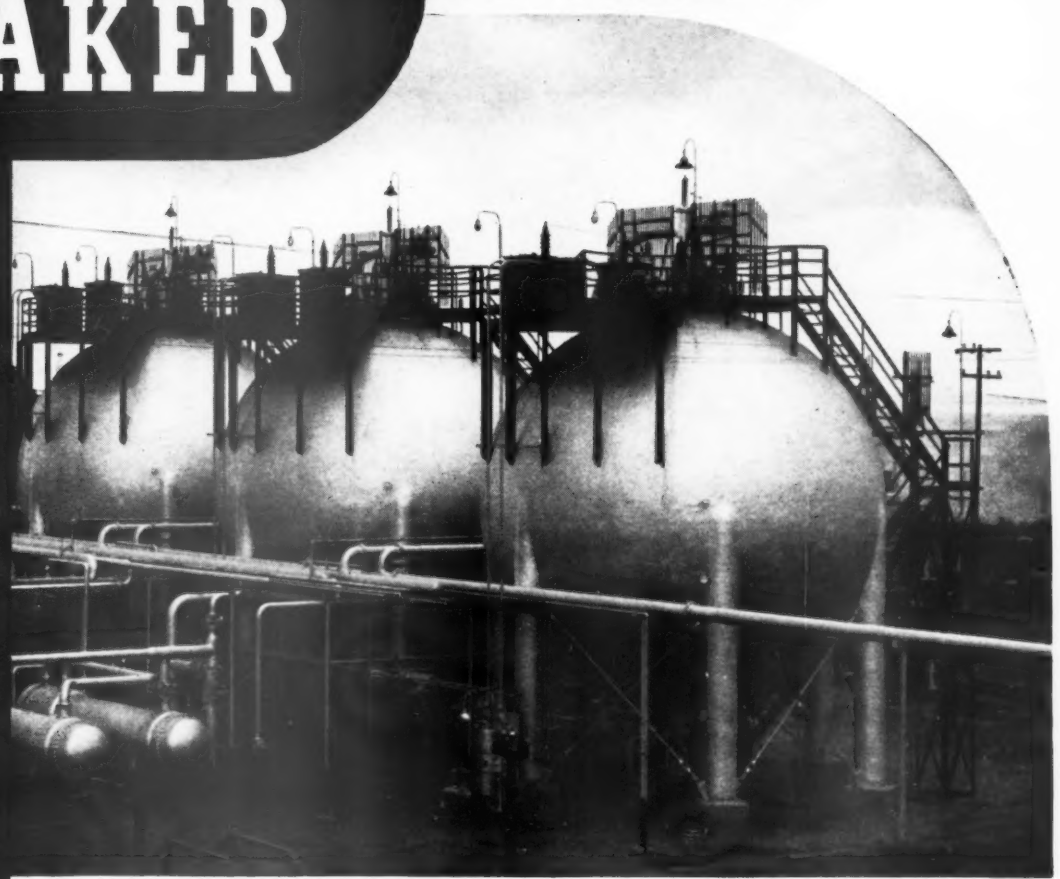
By definition,

$$Z = \frac{P\,V_G\,M}{RT} \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Where: R = gas constant = 10.71.

SALT SHAKER

...NG SIZE...



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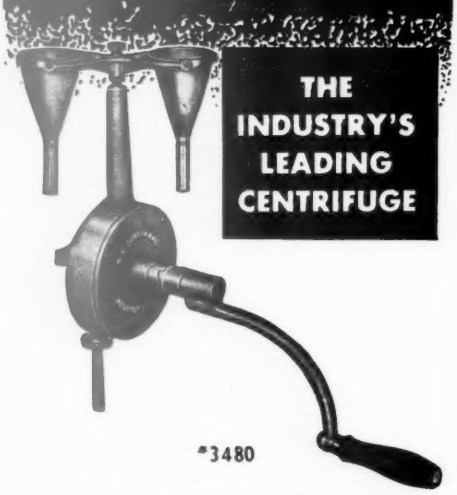

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Equation (6) may be rearranged, and values substituted from equations (7) and (8):

$$\frac{A}{H} = \frac{1}{1001\sqrt{PV_G}} \times \frac{V_G - V_L}{L} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

The ratio A/H may be considered as a multiplier to apply to heat-input rates to obtain a required relief valve area. Equation (9) may be evaluated in the following ways:

a. For any material for which tables of thermodynamic data are available, substitutions may be made from the tables directly into equation (9).

b. The group PV_G may be evaluated from correlations of perfect gas deviation[8]. The second group of the equation, $(V_G - V_L)/L$, may be recognized as a part of the Clausius-Clapeyron equation, from which:

$$\frac{V_G - V_L}{L} = \frac{K}{T} \times \frac{1}{(dP/dT)} \quad . \quad (10)$$

Where:

K is a constant to make the units of the equation consistent.

(dP/dT) is the slope of the vapor-pressure curve.

The pressure - temperature differential may be evaluated graphically from a vapor-pressure curve. Or, it may be evaluated analytically by the differentiation of an imperical vapor-pressure equation. Such a procedure is described by Hougen and Watson[9] and by Perry[19].

c. The latent heat of vaporization may be obtained in the following manner: Equation (3), the Kistiakowsky equation, will give the latent heat for the material at atmospheric pressure. Correlations betwen latent heat and pressure are available[8,10]. These relationships may be used to obtain a correction factor to correct the latent heat at atmospheric pressure to that at the desired pressure. The specific volumes may be obtained as in (b) above [11].

We evaluated equation (9) by methods (a) and (c). By method (a), we calculated "A/H" using Sage and Lacey tabulated data for methane[12], ethane[13], propane[14], isobutane[15], n-butane[16], and n-pentane[17]. By method (c), we calculated A/H for octane at 30, 50, and 100 psia and for pentane at 42 and 95 psia, using Edmister's correlations[8]. The points for pentane calculated by method (c) agreed very closely with those obtained by method (a). The results of these calculations are plotted on Fig. 2, against pressure. A consistent relationship was found, which we recommend for general use. It is represented by the following imperical equation:

$$\frac{A}{H'} = \frac{60}{P} + 0.1 \quad . \quad . \quad . \quad . \quad (11)$$

Where:

A = relief valve nozzle area, sq in.,

H' = heat-input rate, MM Btu/hr,

P = pressure in tank, psia.

The LPG Safety Orders of the California Department of Industrial Relations give the following formula for relief valve area[18]:

$$A = \frac{0.77\,a}{p + 15} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Where:

a = surface area of vessel, sq ft,

p = working pressure of vessel, psig.

A comparison can be made between equations (11) and (12). This is expressed in the following table in terms of the heat-input rates which, when used with equation (11), will give the same relief valve size as equation (12). Two sets of figures are given, depending upon whether equation (12) is construed to apply to the pressure at full valve capacity (i.e., no accumulation) or to the working pressure plus 50 per cent pressure accumulation.

Heat-input rates, which when used in equation (11) will give the same relief valve area as equation (12).

	Accumulation	
Pressure, psi	0 per cent	50 per cent
30	12,206 Btu/hr	14,640 Btu/hr
50	11,830 Btu/hr	15,450 Btu/hr
80	11,300 Btu/hr	15,500 Btu/hr
200	9,620 Btu/hr	13,920 Btu/hr

Equation (11) accomplishes for pressure storage the same thing equation (5) accomplishes for atmospheric storage. Both are expressed as simple functions of a single easily obtained variable. Both give valve-sizing data in convenient units for selecting venting equipment, and both are expressed in terms of a unit heat-input rate of 1,000,000 Btu per hr.

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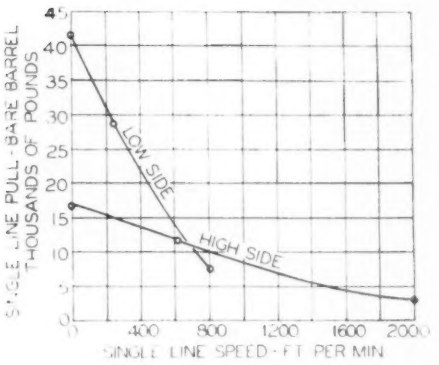
★ ★ ★

New portable rig has safety and light weight

By NICHOLAS A. D'ARCY, JR.



Power curve, portable drilling rig.

RECENTLY placed in operation is a trailer-mounted drilling rig that is one of the first truly postwar oil well servicing and drilling rigs*. This modern semi-trailer-mounted unit is capable of servicing the deepest wells, and it can be used to drill economically to 7500 ft when using 3½-in. drill pipe. The unit complete with 350-hp engine and 96-ft derrick is within the California legal road weight and dimension requirements even when the drilling line and traveling block are included. Widespread use of aircraft type alloy steel, seamless steel tubing, alloy aluminum plate, aluminum structural shapes, and aluminum castings make it possible to reduce the overall weight to below the legal maximum.

EXCLUSIVE

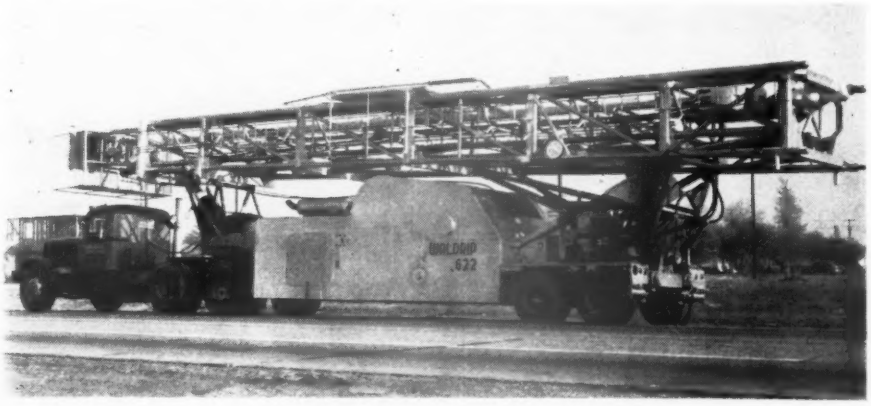
Remote controls, hydraulic drive to the catshaft, shaft drive rotary table drive, hydraulic main drum and sand reel brakes, hydraulic torque converter drive and air clutches are among the other modern developments incorporated into this unit. One of the interesting features of the specifications is that the manufacturer rates it to pull certain loads at a minimum speed of 90 fpm rather than rating it to drill to any specific depth. For instance, it is rated to drill to 5000 ft with 5 9/16-in. drill pipe and pull off bottom with this load at 90 fpm. The same speed in hoisting is obtained from 7500 ft when drilling with 3 ½-in. drill pipe; 12,000 ft of tubing can be hoisted with a hook speed of 72 fpm. These figures are based on performance with engines developing approximately 350 hp. In addition to having sufficient power to pull the deepest wells, the unit is equipped with a sand reel having a capacity of 18,700 ft of ½-in. diam wire line, or 12,000 ft of ⅝-in. line.

*Manufactured by Waldrip Engineering Company, Hollywood, California. The rig is designated as the 622-4.

● **Trailer construction.** One of the outstanding features of this rig is the construction of the trailer. Standard trailer design was disregarded and in its place aircraft design was adapted to trailer construction. The frame is constructed of aluminum alloy plate, which forms the entire skin of the trailer and is the trailer frame. The engine is supported on aluminum structural shapes and the guarding is constructed of aluminum sheet. The gooseneck of the semi-trailer is the only major portion constructed of structural steel. Widespread use of aluminum greatly reduced the weight of the trailer and at the same time provided the required strength by utilizing the full depth of the trailer frame and hoist frame as a structural member.

● **Power transmission.** The engine is situated near the gooseneck of the trailer near the bottom of the frame with the crankshaft of the engine parallel to the longitudinal axis of the trailer. A hydraulic torque converter is attached to the bell housing of the engine and it in turn drives into a reversing gear box. This box provides for a straight through drive in forward speeds and a reverse through heat-treated alloy steel gears. A right angle gear box is used to change the direction of the drive in order to transmit the power to the hoist drums. The right angle box is of the gear and two pinion construction with the right angle drive powering the hoist while the through drive powers the rotary table. Remote controlled clutches make it practicable to operate either the hoist or the rotary table independently or to drive both simultaneously. All these gears are spiral bevel heat treated and are capable of transmitting 325 net hp.

Rear view of drilling unit on the road. Control box is carried on fender to keep unit within legal limits.



● **Rotary table drive.** The rotary table is driven by means of a shaft connected to the output of the right angle gear box. An airflex clutch is mounted on this shaft, which permits engaging and disengaging the rotary table by means of a simple air valve. A vertical chain drive in an oil-tight case is used to transmit the power when the rotary table is on an elevated derrick floor while the trailer remains at the ground level. The propeller shaft drive is made to rotate in a direction permitting any standard rotary table to be used, and the gear ratio provides for table speeds up to 325 rpm.

● **Hoist.** The hoist proper is of two-drum construction with a 46-in. long, 17 ¾-in. diam main drum and a 44-in. long, 15-in. diam sand reel drum. The drive from the right angle gear box to each hoist shaft is through multiple strand roller chain operating on cut tooth flame-hardened sprockets. The sand reel drive is equipped with a clutch on the countershaft to provide for disengaging the sand reel drive while hoisting. The drums are mounted on large diameter trunnions, which are built into the aluminum trailer frame. No drumshafts are used and this reduces the overall weight of the unit. The main drum is equipped with a heavy-duty airing clutch on each end of the shaft, which provides two speeds to the main drum. The unit can be shifted from one speed to the other without stopping and the spread in ratio between high and low is approximately 2.6 to 1. The sand reel has a single airing clutch and a single hoisting speed. The torque converter provides a range of speed on the sand reel of between 353 fpm and 1280 fpm even though but a single mechanical speed is provided.

Full wrap brakes are actuated by hydraulic pressure and the brake lever is placed at the control panel at the front derrick leg. Flame-hardened alloy steel brake rims insure maximum brake rim life.

The hoist has a stalled single line pull of 45,000 lb in low gear and more than 30,000 lb pull at 200 fpm line speed. These pulls and speeds are based on engines developing 350 net hp. The use

of hydraulic torque converter makes it practicable to drive the hoist with but two speeds on the main drum and it also reduces the shock load imposed on all portions of the unit.

● **Engines.** The first 622-4 unit delivered by Waldrip was powered by a 12-cylinder, 2-cycle twin diesel engine that is capable of developing a maximum of 385 hp at 1800 rpm. Other engines of similar horsepower capacity can be used but light weight high speed engines are most suitable for this type of drive. A 12-cylinder 2180 cu in. displacement natural gas or butane engine is also available for this unit, and it will develop well over 500 hp at 1600 rpm. Both engines have a weight under 7000 lb. and this is essential if the complete unit is to remain of a legal weight.

● **Controls.** Two sets of controls are standard equipment with the 622-4 drilling rig. One set of controls is at ground level on the main trailer frame, and controls all functions pertaining to raising and extending the derrick. The other set is the main drilling controls, which are grouped into a panel that may be placed at any convenient position for the driller. When high derrick floors are utilized these controls are generally situated at the front right-hand derrick leg and at about waist level above the derrick floor. If the unit is used for servicing deep wells and the high derrick floor is not required the main control panel would be at waist level when the operator is on the ground.

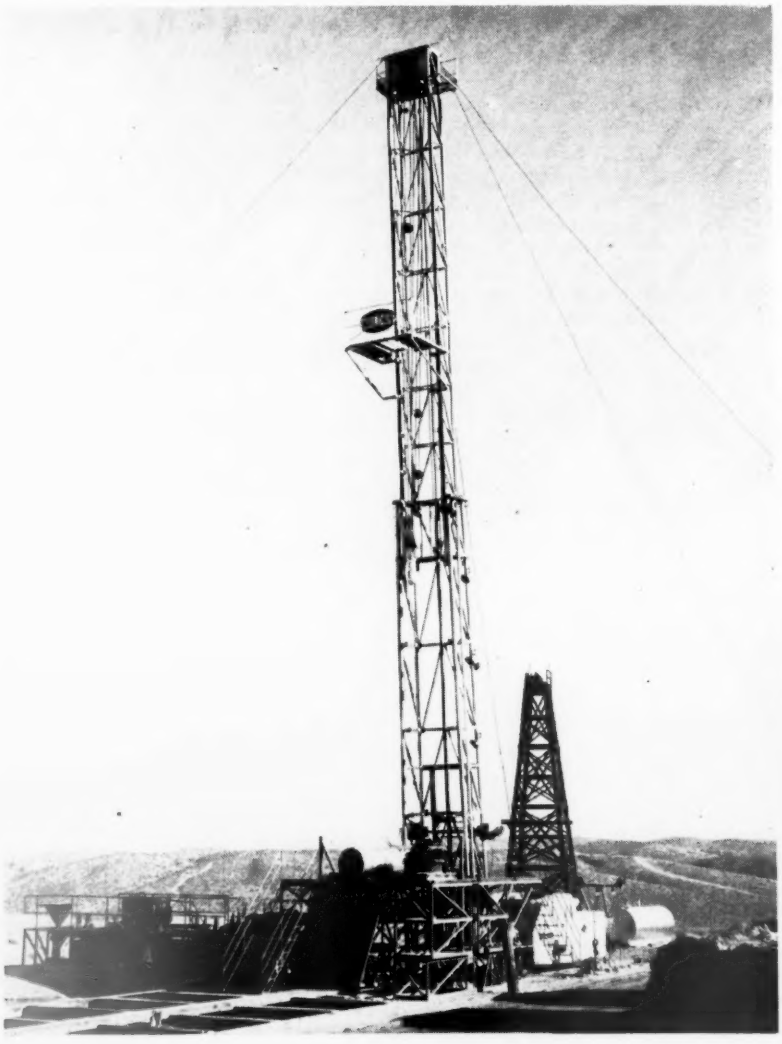
The raising controls include the hydraulic engine throttle control, air controls for both drum clutches and sand reel clutch, rotary table clutch, and the torque converter brake control in addition to the controls for the derrick raising screw and the air motor, which extends and telescopes the upper derrick section. The main drilling control panel includes in addition the hydraulic brake levers for both the sand reel and main drum brakes and the cathead controls, but this panel does not include controls for raising or extending derrick.

Air clutches are used on all the drum drives and for the final clutch on the rotary table drive. These are all controlled by balanced air valves that control the pressure of air admitted to the clutches. The engine throttles are controlled by hydraulic controls and they can be actuated either by hand valves in connection with the air clutch control or by a separate foot valve. Hydraulic controls are also used in connection with the derrick extending motor, the main gear box shift, and the right angle gear box clutches. The main drum brakes are controlled by means of balanced air valves actuating hydraulic mechanism and the sand reel brake is actuated by direct hydraulic control. Both brakes are controlled by small levers that can be placed at remote positions to meet changing drilling or servicing programs.

The catheads are mounted on a separate catshaft, which is driven by a hydraulic motor. The hydraulic pump, which supplies power to the catshaft motor, is driven from the main drive line at speeds not affected by shifts in drawworks speeds. This shaft can be raised or lowered, when the unit is built, to accommodate drilling floors of various heights and its speed can be controlled independently of the speeds of other drilling operations. A friction break-out cathead is mounted on the rotary side and a friction spinning cathead is on the driller's side.

● **Derrick.** The 96-ft, 240,000-lb hook load capacity derrick is constructed entirely of seamless alloy steel tubing to obtain maximum strength with minimum weight. It is estimated that approximately 7000 lb was saved in the derrick construction by using alloy steel aircraft-type tubing and aluminum alloy plates and shapes. The derrick is of two-piece telescoping all-welded construction. Four guys are required for stability although the derrick has a factor of safety greater than unity when unguyed.

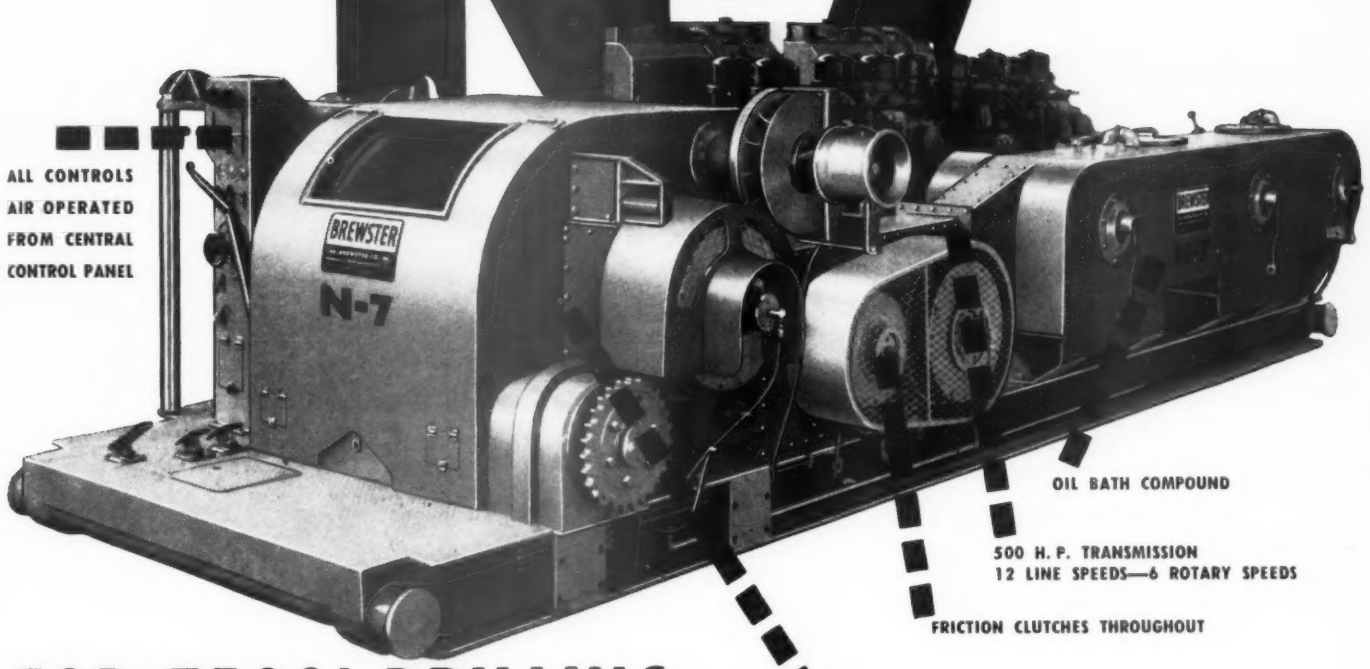
One of the interesting features of the derrick is the crown block construction. This item is at a critical point with respect to weight when raising the derrick.



Front view of outfit when rigging up. Drilling mast and rotary table are set on 10-ft light weight substructure.

View shows power control box, rotary tachometer, and spinning cathead. Controls visible are: Main drum brake, sand reel brake, sand reel clutch and throttle, main drum clutch and throttle, rotary drive control.

BREWST[illegible] ANCED [illegible] SIGNING INCREA[illegible] L[illegible]N[illegible] ROFITS!



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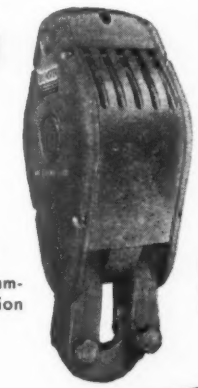

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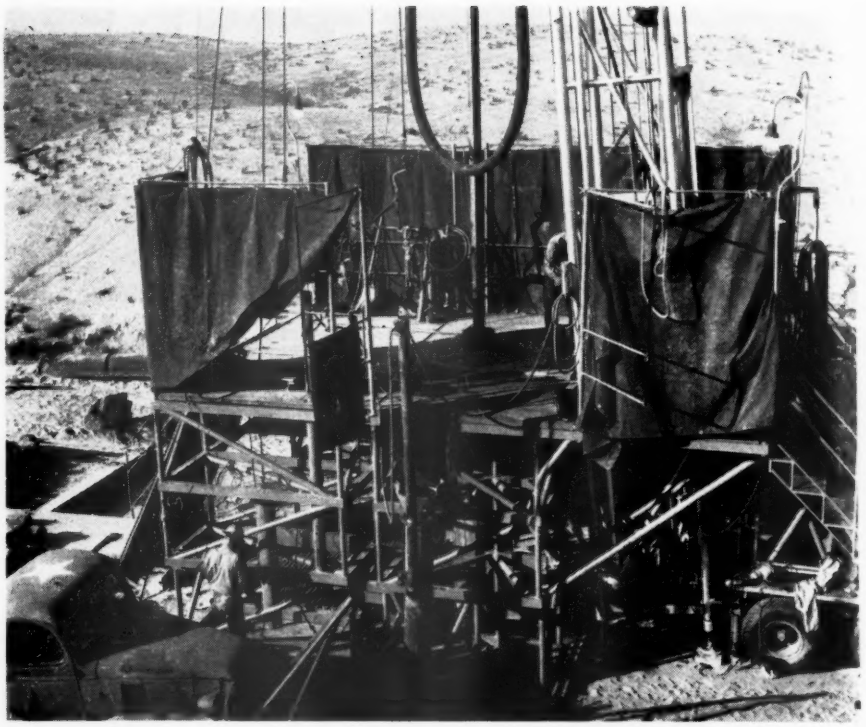
and it is built largely of aluminum alloy plates and shapes. The entire crown block structural frame is fabricated from aluminum plate, and the catline sheave and highline sheave are both made from cast aluminum. The 30-in. diam casing line sheaves are of alloy cast steel and are mounted on anti-friction bearings. The crown block sheave pin is a heat-treated alloy steel tube to conserve weight.

● **Derrick safety features.** Safety precautions have been provided in the derrick both to prevent dropping it while extending and telescoping the upper section and to prevent dropping the telescoped sections while raising and lowering. The derrick is raised to the drilling position by means of a built-in screw mechanism operated through a power take-off in the main transmission line. This screw mechanism is controlled from the ground controls and is so designed that any failure in the power transmission would automatically hold the derrick in whatever position it might be at the time. The screw also controls the motion of the derrick past the vertical and into the drilling position without the need for back guys or other mechanism. It is impossible to raise or lower the derrick when power is not being applied to the raising screw.

The upper section is extended by means of a hydraulic motor driving through a reduction gear to a sprocket. The sprocket engages a chain permanently mounted to the upper section and causes the derrick to climb upward as the sprocket drives into the extending chain. The same motor can be reversed to lower the upper section. The bottom of the chain engages a spring that retracts a dog while the tension is applied to the chain. In case of failure in the raising mechanism the tension would be released from the spring and the dog would engage in a rachet before the derrick could drop more than 4 in. This safety catch is fully automatic, and it has been proved on several drilling installations.



Rotary floor and light weight superstructure.

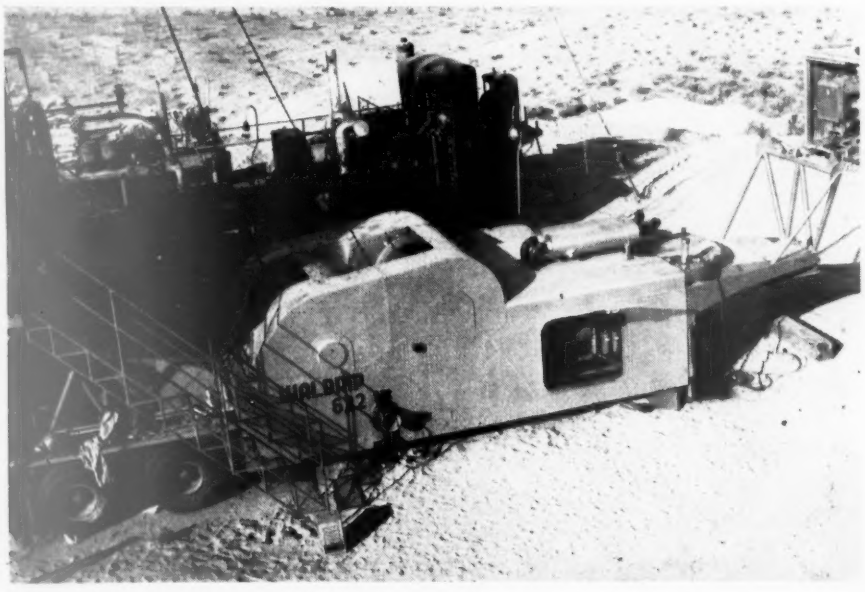
When the derrick is fully extended safety locks automatically engage the bottom of the top section to hold it in the engaged position. All raising and lowering operations are performed from the ground, and they can be done before rigging up. Leveling screws are provided in the foot of each of the four derrick legs to insure even bearing and uniform loading of the derrick.

● **Tubing platform.** The tubing platform is permanently fastened to the derrick, and it is lowered and retracted automatically as the telescoped derrick is raised and lowered. The platform drops into the horizontal position when the derrick passes the vertical position when raising, and it retracts when the derrick is lowered to a position in which the center of gravity of the platform is beyond the hinge point. An air drag cylinder, with a built-in inlet and outlet orifice, controls the speed with which the platform lowers and retracts. The action is built-in and automatic, and it is not controlled from the ground in any way.

● **Derrick floor support.** The derrick floor support and the stairs leading to the derrick floor are made of tubing in order to save weight. The derrick stairs are so light that one man can raise a 10-ft section into place with a hand line. The entire 10-ft high derrick sub-structure has been lifted and moved by three men, two bars, and six pipe rollers. All sections of this structure can be loaded easily by means of an A-frame or truck winch lines.

● **Conclusions.** This new unit is certainly postwar in all respects, and it reflects mature and progressive engineering thought and competent manufacturing. Many of the features, such as the alloy-steel seamless tubing derrick, aluminum trailer framework, light weight sub-structure, remote drilling controls, and hydraulic drive to the cat-shaft are departures from conventional construction, but they are sound deviations, and all have been subjected to careful engineering calculations and rigid operating tests. The safety features in the derrick are worth close examination, and the light weight of the overall unit should prove popular with operators who are faced with moves over the main highways. ★ ★ ★

Trailer and hoist frame with aluminum construction. Twin diesel inside.



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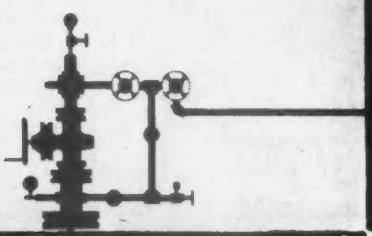

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Standard name changed

The name of the Standard Oil Company of New Jersey has been changed to the Esso Standard Oil Company, it is announced by M. J. Rathbone, president of the company. The change was made to give formal recognition to the close association that has developed in the public's mind over a period of years between the corporate name of the company and its Esso trade-mark.

"The trade-mark Esso—first used in 1925 as the brand name for our premium motor fuel—has been given to more and more of the company's products until today it is the name under which our products are sold for use in cars, homes, farms, factories, ships, airplanes and many other uses," said Rathbone. "Its acceptance by the public has been so great," Rathbone added, "that Esso has been practically synonymous with the corporate name of the company."

Heads press relations

Hank Cabot, director of public relations for the Brown Instrument division of Minneapolis-Honeywell Company, has been appointed chairman of the press relations committee for the 1948 National Conference and Exhibit of the Instrument Society of America, E. J. Grace, chief instrument engineer of the Sun Oil Company and chairman of the ISA meetings committee, announces.

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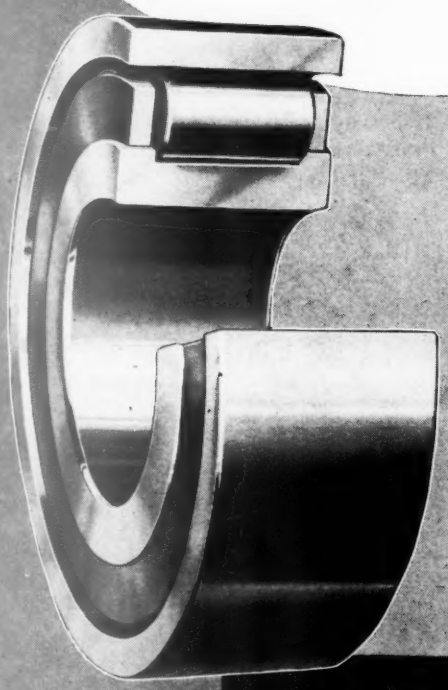

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An oil field service organization has opening for petroleum engineer in technical oil field service. Applicant must have some experience in oil production and degree in petroleum engineering. Permanent position with long established company. Write giving full details on education, experience, age and marital status. Attach small photograph. Address replies to Box 80, c/o *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

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It Is ALWAYS Sealed Off!

DID SOMEONE FORGET?

MEMO FROM A SAFETY ENGINEER'S NOTEBOOK...

RECORDS SHOW THAT IN THE EXCITEMENT OF EMERGENCIES, EVEN THE MOST EXPERIENCED PERSONNEL DO UNPREDICTABLE THINGS -- OFTEN FORGETTING TO PERFORM THE SIMPLEST OF SAFETY OPERATIONS UNTIL TOO LATE. PARTICULARLY WHERE SUCH OPERATIONS ARE PERFORMED INFREQUENTLY AND HAVE NOT BECOME SECOND-NATURE BY DAY-AFTER-DAY REPETITION, THE CHANCES ARE MUCH GREATER THAT SUCH OPERATIONS WILL BE COMPLETELY OVERLOOKED WHEN SUDDEN EMERGENCIES OCCUR.

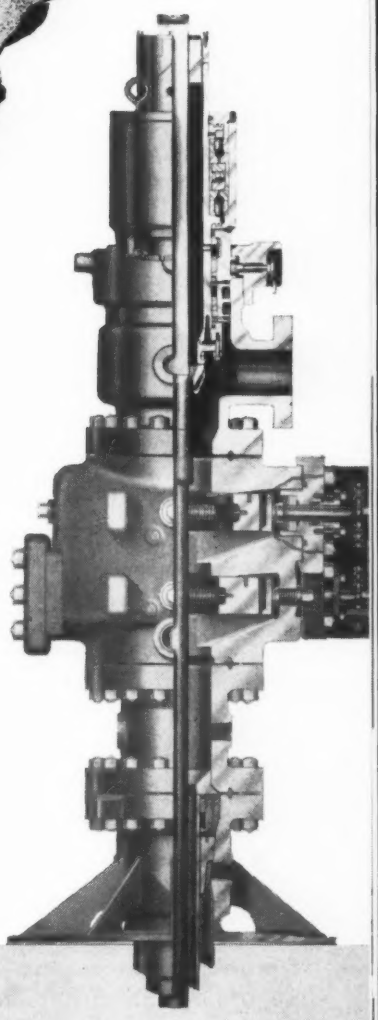
THE ONE BEST SOLUTION TO THIS PROBLEM IS ELIMINATION OF ALL HUMAN-DEPENDENT OPERATIONS WHEREVER POSSIBLE.

OPERATORS TELL US that of the *many* vital features built into the Shaffer Combination Rotating Blow-Out Preventer and Stripper, none is more important than the fact that it is *completely automatic* in its operation. Regardless of whether the drill string is rotating or not—regardless of whether it is being raised or lowered—regardless of whether plain pipe, couplings, tool joints or even square, hexagon or octagon kellys are in the sealing unit . . . pressure emergencies *simply cannot happen too fast* for the Shaffer Combination Rotating Blow-Out Preventer and Stripper *because it is ALWAYS sealed and packed off around the various elements in the drill string.**

There are no valves to turn, nothing to tighten or loosen, no operations to remember—or forget—when pressure emergencies arise. It's the most positive and foolproof Blow-Out Preventer yet developed!

And check below some of the many other unique features of the Shaffer Combination Rotating Blow-Out Preventer and Stripper. By every yardstick it is the most advanced blow-out protection you can install on your wells.

** Excepting, of course, such abnormally large diameters as bits and reamers.*



The Shaffer Type 46 Combination Rotating Blow-Out Preventer and Stripper with the Shaffer Double Cellar Control Gate and Shaffer Combination Landing Base Head—the ideal pressure control hook-up for modern drilling operations.

Additional Unique Advantages

Seals Around Any Shape: The Shaffer Combination Rotating Blow-Out Preventer and Stripper expands and contracts automatically to maintain its pressure-tight seal around any shape and any diameter in the drill string (except such abnormally large diameters as bits and reamers). It seals off around square, hexagon, or octagon kellys—around pipe, couplings, tool joints and drill collars . . . all without manual adjustments of any kind!

Continuous Seal: As outlined above the seal around the drill string is always maintained while the drill string is in the hole. This continuous seal and automatic adjustment permits the drill string to be stripped in and out of the well without pressure leakage. Yet the pipe is run in the same manner as in conventional drilling operations!

Quick Release: To run such large tools as bits or reamers through the unit, simply pull a spring latch, rotate the bonnet 1/6th turn and the complete rotating assembly is readily withdrawn from the body above the bit or reamer. When going back into the hole simply reverse the operation. It's quick. It's simple!

Space-Saving Compactness: Not only is the Shaffer Combination Rotating Blow-Out Preventer and Stripper unusually compact, but flow connections incorporated directly into the body eliminate need for spools or other accessories for overflow connections. Vertical height of drilling riser is kept at a minimum!

Negligible Wear: Since the Stripper Rubber rotates with the kelly—not around it—there is practically no wear on the rubber. Maintenance is negligible!

Space does not permit describing all the advantages built into this unit . . . the unique bearing design that absorbs both radial and thrust loads . . . the flexible steel latches that protect the Stripper Rubber against extrusion . . . the positive kelly drive that handles all driving loads . . . and many other advantages. See your nearest Shaffer representative for the full story or write direct!

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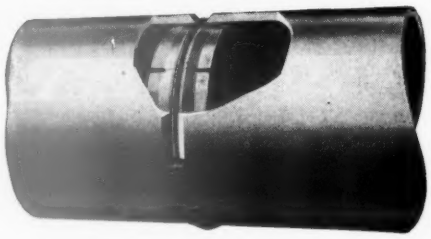

weld penetration of the entire circumference of pipe. They also make it possible to align pipe faster. In case of shock, strain or vibration the pipe will fail before the joints. Today many Engineers specify thin wall pipe with WEDGE CHILL Rings for greater line strength, in addition to lighter weight and lower costs.

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Adds to sales force

Boris B. Zelman has joined the Federal Telephone and Radio Corporation, Clifton, New Jersey, affiliate of International Telephone and Telegraph Corporation, to act as sales engineer for mobile radiotelephone equipment, covering the states of Indiana, Michigan, Kentucky, and Ohio. His operations will be carried on from FTR's office at 100 Kingsland Road, Clifton. Zelman was formerly associated with Design Associated, Ltd., New York City, and was in charge of the development division. Zelman, a native of Seattle, Washington, is a graduate of Columbia University and the New York University, where he studied engineering.

B. B. Zelman

Gulley joins Rockwell

H. Boezinger, Pacific Coast district manager for the Nordstrom Valve Division, Rockwell Manufacturing Company, has announced the employment of William F. (Bill) Gulley as sales engineer. Gulley attended Stanford University and the California Institute of Technology where he was graduated with the degree of bachelor of science in mechanical engineering. At both Stanford and California Tech he was active in athletics and starred in football. During the war he spent three years in the Navy in an engineering officer capacity aboard an aircraft carrier.

W. F. Gulley

Gulley is a "native son" and has wide acquaintance in Southern California.

His work will be chiefly connected in contacting the engineering offices of oil companies and engineering concerns specializing in refinery construction. He will operate from the Los Angeles district office.

To overseas staff

Edmund Burke, Jr., petroleum and chemical engineer, has joined the staff of General Motors Overseas Operations, according to an announcement by Earl E. Eby, manager of power and industrial equipment. Burke will be responsible for the sale of General Motors Series 71 diesel oil field engines to foreign accounts in the New York area.

Edmund Burke, Jr.

In 1933 Burke graduated from the mechanical engineering school at Alabama University with a B.S. degree. After spending six years in various fields of the petroleum industry, he established his own petroleum sales engineering business in Chicago and later moved his office to New York. He entered the Army Air Corps in 1941. After release from active duty in November, 1945, with the rank of major, Burke re-entered his own business in New York where he remained until joining General Motors in February of this year.

Burke resides in White Plains, New York and will operate from the General Motors Overseas Operations offices in New York City.

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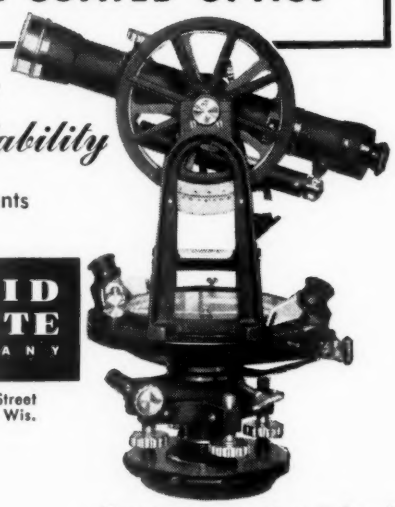

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NEW EQUIPMENT

(1) Tool kit

A new all-purpose tool kit that facilitates the repair and maintenance of machinery has been announced by Ingersoll-Rand Company. The kit is compact and portable. It includes the new electric impact tool—with standard accessories for drilling steel, masonry or wood, reaming, wire brushing, nut-running and nut-removal, tapping, driving and removing screws, extracting broken cap screws and studs, and hole saw work.

The kit is assembled complete or with accessories as required. With standard equipment, the kit contains the impact tool with a Jacobs collet type chuck, six hex sockets of varying sizes, a Morse Taper socket, and adapter sleeve. If some items are already available, price allowance is made on those omitted.

The photograph shows a completely outfitted kit containing all standard equipment plus twist drills, reamers, tops, carbide-tipped masonry drills, hole saws, screw and stud extractors, wood bits, and wire brushes. The kit also contains screw drivers and quick change

chuck, square Phillips and Reed and Prince bits, together with screw driver adapter for these bits. A universal joint and anvil extensions are available.

The impact tool is the only Universal motor driven, all-purpose tool employing the impact mechanism. It plugs into any a.c.-d.c. electric socket and runs as any conventional electric tool till the going gets tough. Then the impact mechanism automatically functions and delivers 1900 rotary impacts per minute to the job. This rotary power is essential to perform difficult jobs, without torque effect to the operator. Because of the ease and speed with which the work can be handled, it enables the operator to do any job faster and with less effort. There is no kick, no twist transmitted back to the hand under any condition, and the motor continues to run even when the spindle is stalled. This eliminates motor burn-outs, which are a frequent cause of electric tool failure.

The impact tool is available with either 110-volt or 220-volt motors as required.

(2) Drive conversions

Marmon-Herrington Company, Inc., originator of All-Wheel-Drive conversions for Ford vehicles, has announced that it is now in production on the All-Wheel-Drive conversions of the new 1948 Ford models. Marmon-Herrington All-Wheel-Drive places driving power in the front wheels as well as the rear. This increases immensely the tractive power of the vehicles, enabling them to negotiate deep mud, sand or snow, steep hills, and mountain grades with exceptional speed and ease—to perform as efficiently and reliably off the highway as on. Marmon-Herrington All-Wheel-Drive converted Fords are used principally on work that is too difficult for vehicles of conventional drive.

(3) Pressure bomb

A pressure bomb with a surface recorder that, it is asserted, will save oil producers from two to five hours on each test, for either water shut-off or production, has been developed by the McCullough Tool Company and is now in use in California oil fields.

The new tool embodies these primary features.

Instead of having the pressure recorder installed below the packer down in the casing, the recorder is above ground, where all pressure variations that occur during the test are instantly registered on a chart, in clear view.

The chief saving in time and money is that while the subsurface recorder must be brought to the surface and examined before any further progress can be made, the surface recorder enables the operator to get the next operation under way immediately, while the tester is being withdrawn from the well. It is at this point that a saving of time ranging from two to five hours, depending upon the depth of the testing point (in extreme cases, as high as eight hours), is effected.

The device operates in the following manner:

The testing tool, including the pressure-sensitive element and the gun perforator, is run into the well on the operator's drill-pipe or tubing to a point at which the holes are to be shot. Then a sinker bar and electrical contactor is run into the well on the regular perforating wire line.

When the sinker bar sets down on a companion connection in the testing

tool, continuity is established between the electric firing assembly in the gun perforator, the pressure-sensitive element, and the electric operating and control instruments at the surface. The gun perforator is fired in the usual manner by pressing the buttons in the shooting panel.

The recorder instantly shows that the gun has been fired, and starts to draw a curve of the pressure to which the pressure-sensitive element is exposed. The first pressure shown is that of the natural hydrostatic head in the well.

After the gun is fired, the operating string is moved upward a few feet and the tester is set, excluding the original hydrostatic pressure from the bomb and exposing the bomb to the rock or formation pressure below the packer.

If the test is dry, there will be little or no change in pressure shown on the chart as time passes; but if wet, the recorder will indicate a continuous increase of pressure until the column of fluid rises inside the operating string to a point where the pressure created by the fluid head equals the rock pressure and the column becomes static, or until the fluid flows over the top of the operating string.

Lowering equipment into well.

(4) Mass spectrometer

A new recording mass spectrometer capable of measuring over the mass range from 1 to 350 and adjustable to any portion of that range, has been announced by the Special Products Division of the General Electric Company. This new instrument incorporates the control and stability features that have made the mass spectrometer a practical method for the chemical analysis of gases and vapors in the rapidly developing fields of atomics, nucleonics, and ionics.

The new instrument, a development of the company's General Engineering and Consulting Laboratory, is applicable to general chemical analysis and isotope abundance measurements. The mass spectrometer method of chemical analysis often reduces the number of time-consuming steps of complicated reaction and reduction processes to a single electrical separation with automatic recording of mass constituents, all completed in a few minutes' time.

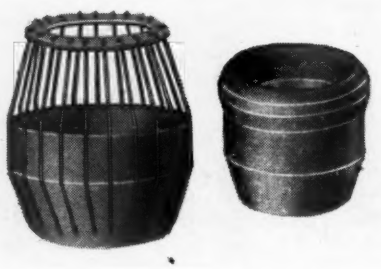
The instrument is built in two main units for easy inspection and maintenance. The control unit contains the electronic components and recorder, while the tube rack houses the spectrometer tube, vacuum pumps, gages, sampling system, and other components.

(5) Packer cup

The new Guiberson Corporation type "GW" packer cup used with the company's type "K" swab, is now being produced in all standard sizes, Al Pranger, sales manager, has announced. First marketed in a few sizes only, the now complete size range of the "GW" packer cup has been made available to meet widespread requests from operators, it is stated.

Guiberson spokesmen are enthusiastic about the new packer cup, explaining that it is "ideal" for use in swabbing old wells, or when used in wells containing strings of mixed or bad pipe. Due to the tight fit against the tubing or casing wall made possible by the properties of this flexible lip cup, it is especially valuable in swabbing wells with a low fluid level or in taking water off gas wells, they have found.

It was pointed out that this new cup has been designed for special jobs and does not supplant the standard type "K" packer cup for routine swabbing operations. Both cups are made of the same oil-resistant materials and in sizes to fit all tubing and casing dimensions, Pranger states. Greater value is claimed for users of the type "K" swab with the addition of this "GW" packer cup as an added accessory, because it is readily interchangeable with the type "K" packer cup.



Type "K" cup. Type "GW" cup.

(6) Fire extinguishing

American-LaFrance-Foamite Corporation announces a completely new carbon dioxide fire extinguishing system for protecting Class "B" and "C" risks requiring localized or total flooding, and for rotating electrical units requiring a sustained discharge of carbon dioxide.

This new system, according to the manufacturers, automatically shuts off power units, closes windows and doors when fire strikes, but only after first sounding an alarm to permit employees exit from the fire area. Then the system discharges its fire-killing carbon dioxide.

It is a flexible unit, readily adaptable to all needs a fire risk requires. It can be easily installed and serviced. Additional cylinders can be quickly added should a risk be increased later to require added protection.

More Profits with a.....

JENSEN

By using power more efficiently, reducing wear on polish rod, stuffing box and other parts and keeping service costs at a minimum, Jensen Pumping Units do cut production costs.

Naturally, if production costs are reduced, profits are increased. And that's exactly what a Jensen will do—give you more production profit.

A booklet giving details on Jensen advantages can be had by contacting your near-by dealer or writing to Coffeyville. Phone or write today.

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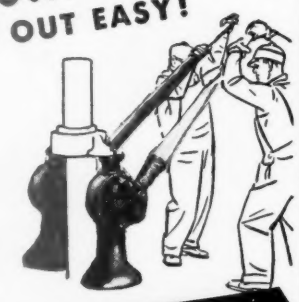

with

Simplex GEARED JACKS

● Pulling casing, skidding rigs and other heavy-duty lifting jobs are done faster and easier with Simplex Geared Jacks. These single-acting, ratchet-lowering jacks are famous for power, safety and ruggedness. Furnished with oval sockets and extra-strong 6 ft. oval hickory poles; capacities to lift up to 35 tons as much as 16 inches. Ask your supply house for details, or write for Bulletin Oil-45.

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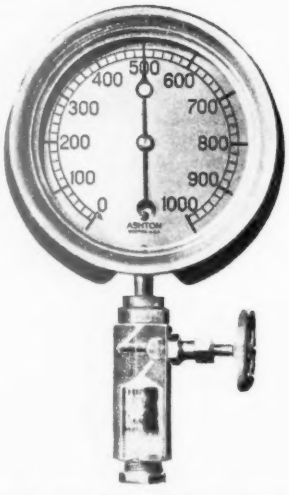

Simple, non pinch-off, low cost micro-control valve for smoothest boiler plant performance.
Eliminates pulsation "jitters."
Write for descriptive bulletin.
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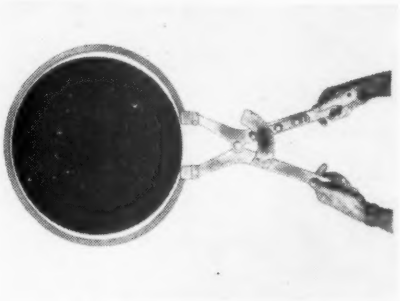
(7) Piston ring expander

A new and important aid in the maintenance of large gas engines, diesel engines, and compressors, is a piston ring expander that has been developed by the Thilenius Equipment Company. "X-Pano", as the product is called by its manufacturer, provides easy installation and removal of piston rings of any size from 7 to 24 in. diam., and



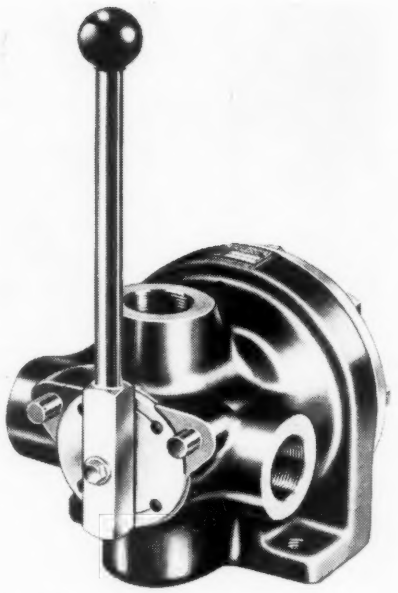
greatly facilitates overhaul work on any type of large gas or diesel engines.

Constructed of durable aluminum alloys throughout, X-Pano will not corrode in either land or sea duty. The piston ring expander weighs but 1½ lb and has an overall length of 19 in. A special ratchet feature permits holding the ring in any expanded position desired.

(8) Selector valve

Features of the 1½-in. 4-way selector valve No. 8298, manufactured by Saval Company, are low handle load, ball bearing construction, and rugged stops and balanced detents for all three operating positions. A force of only 35 lb on the 12-in. handle actuates the valve at 5000 psi pressure.

Designed for corrosion-resistant service with water, oil, or gas, this valve has a forged steel body with heavy duty construction throughout. It employs Saval's patented "Shear-Seal" principle, which provides a metal-to-metal seal that is self-aligning and automatically compensates for wear. The valve is not critical to dirt because foreign materials are wiped away instead of lodging between surfaces.



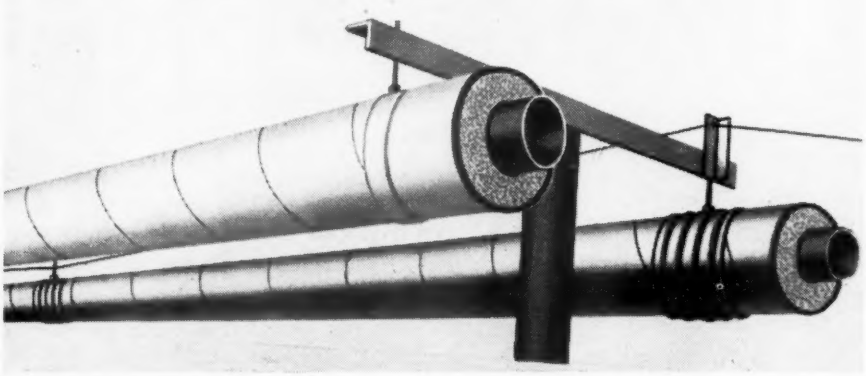
The valve has only one basic moving part and may be serviced without removing from lines. It requires no lubrication or packing adjustment throughout its life. The manufacturer's test indicates life expectancy of more than 1,000,000 cycles under the most severe operating conditions. Modifications are offered to meet special requirements.

(9) Foilclad pipe units

An exclusive feature of Ric-wiL Foilclad pipe units for overhead distribution of oil, viscous fluids, process liquids, and steam, lies in the fact that pipe in these units is insulated at the factory to meet individual project specifications. A recent development of the Ric-wiL Company, Foilclad units are shipped in 21-ft sections, completely prefabricated and ready for installation with only one handling required at job site. Time and cost of installations are thus minimized.

In the prefabrication of these units at the Ric-wiL factory, asbestos, cork, or other insulation, as specified, is machine coated with high temperature asphalt and tension wrapped with asphalt-saturated asbestos felt. A second coating of asphalt is followed by a tension wrapping of aluminum or copper foil, which forms a perfect bond with the asphalt. The result is a highly efficient, durable unit waterproof and weather protected.

A variant of the basic type of Foilclad unit employs a pipe supported within a pipe with insulation around the outer pipe. In this way any desired temperature can be maintained within the pipes. Either pipe can carry the process fluid while the other carries the heating or cooling medium.



Bulls-eye

WITH THE NEW

LARKIN CENTRALIZER

THE sole function of a casing centralizer is to center the casing in the hole in which it is set—and to do so without injury to the well bore.

THAT'S WHY—for centering strength, the Larkin Long Type (Bull's-Eye) Centralizer is constructed with two spring sections in tandem. The shorter arc gives greater strength. There are twice the usual number of arcs—offset to give greater peripheral bearing on the wall of the hole and from *four to twenty times the centering strength of other centralizers.*

THAT'S WHY—to prevent injury to the well bore, the Larkin Long Type Centralizer is equipped with straight rather than helical spring valves. This eliminates the scraping action inherent in the construction of centralizers with helical staves.

THAT'S WHY—for rugged durability, the Larkin Long Type Centralizers are constructed with 1½" x 3/16" high quality spring steel staves, *riveted, not welded,* to sturdy end and center rings.

THAT'S WHY—Larkin's Field Representatives, after coming off a complicated cementing job, can report as follows—"*12 of our long centralizers were run to bottom, pulled and later rerun. When they reached the surface they looked like new—well was 8,547' deep.*"

On the same job another man reports—"*They saw the centralizers after the round trip, and were especially complimentary about their condition. The centralizers were not distorted in any way, and turned as freely on the pipe as when they were installed. The paint was rubbed off the staves where they contacted the wall of the hole.*"

THAT'S WHY—after field and laboratory tests made on Larkin Long Type (Bull's-Eye) Centralizers by oil company engineers, another representative can report as follows: "*The pipe was run 7,000' under normal conditions. After reaching bottom the casing was rotated for better than two hours. The result was that when the joint was returned to the surface all centralizers were in good shape and the use of centralizers that can be rotated through will be highly recommended.*"

"*A compression and deformation test was made—Ours withstood better than 2,000 pounds more weight than any of the others. This test placed ours above all the others.*"

THAT'S WHY—it is to your advantage to use Larkin Long Type Centralizers *to center your pipe.* They will increase the efficiency of other tools & methods that might be employed to better your cement job.

Larkin Centralizers are available through Supply Stores everywhere.

LARKIN

...Through Your Supply Store

LARKIN PACKER CO., INC.

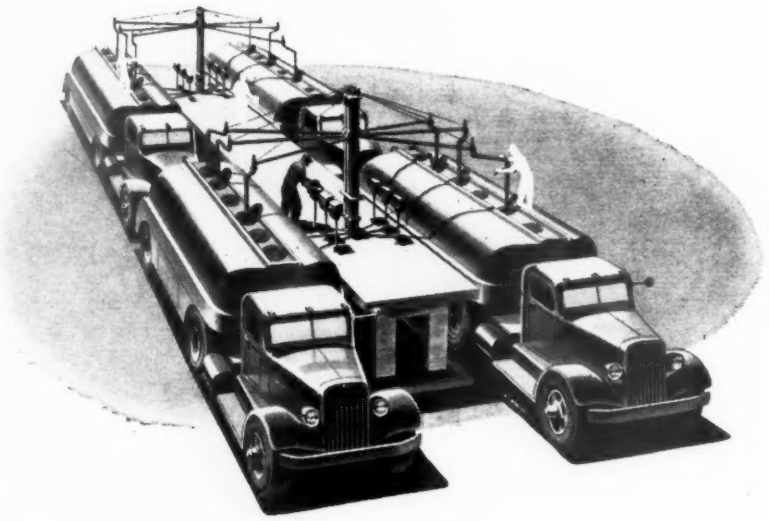
ST. LOUIS, MO.

how to be

4 PLACES AT ONCE!

✻ CONTROL TRUCK LOADING AT FOUR STATIONS WITH ONE ATTENDANT, THIS SAFE, FAST, TIME-SAVING WAY

When truck loading meters are equipped with SMITH AUTOMATIC SET STOP and VALVE the delivery is automatically controlled. Simply set the compartment capacity on the predetermining counter and move the control handle. The pump is started and valve opened. When delivery reaches completion the flow is slowed down, topping the compartment — valve closes on **exact** gallon and stops pump. Duplicate tickets are printed showing the exact amount delivered with product identified—your copy providing you with an infallible accounting system. May we tell you more about it?



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(10) Liquid level alarm

A new device to set off warning signals—bells, sirens, or warning lights—when liquid levels in small boilers or various types of tanks reach predetermined low or high levels has been announced by The Reliance Gauge Column Company. Known as the "Levalarm", the device can be used on pressures up to 250 psi. An electric switch is operated through the agency of a permanent magnet when a monel float rises or falls in a separate float chamber. The switch can be wired for a normally open or normally closed circuit—is dust, vapor, and explosion-proof. Levalarm is said to be sturdily built but sensitive to slightest water level variation.

(11) Rotating scratchers

The new B & W rotating scratchers are designed to improve the cementing or completion operation by removing the mud cake from the formation face just as the cement is placed, with the result that the cement is well set and closely bonded to the clean formation.

As shown in the photograph, a series of strong, multiple-strand spring steel wire units are mounted on 5-ft base strips. These strips are spot-welded to the casing or tubing throughout the section or sections of the hole where a complete cement seal is necessary.

In operation, the pipe equipped with rotating scratchers is run to cementing depth and rotated while the cement is pumped into place. The mud cake re-

moved from the formation face is displaced ahead of the rising cement.

B & W rotating scratchers have three major usages: (1) Mounted on casing and rotated during the circulating, cement mixing, and displacement periods. (2) Mounted on a tubing "stringer" subbed to the drill pipe and rotated while placing a cement plug in open rotary-drilled hole. (3) For cleaning rotary-drilled hole through lower pressure oil sands prior to setting the well screen or slotted liner.

The equipment is manufactured by B & W Incorporated.

(12) Diesel fuel additive

The use of Induco Fluid, a new diesel fuel oil additive, has helped Rocky Mountain Drilling Company establish a flock of records: First, the drilling of California's deepest oil exploration near Ventura (present depth of 17,696 ft); second, continuous drilling operation that has broken all previous records (six heavy-duty diesel engines have been kept on uninterrupted 24-hr service for seven months); third, only three engine oil changes have been made during this entire period (one at 1500 hr, another at 1600, and the last at 1700 hr).

During this entire gruelling non-stop push, engine checks indicated perfect combustion throughout, increased power output, sustained white smoke and a complete absence of motor sludge. According to Roy C. (Buck) Carpenter, pusher for Rocky Mountain, the company began using Induco Fluid in July, 1947, the beginning of the record-breaking run.

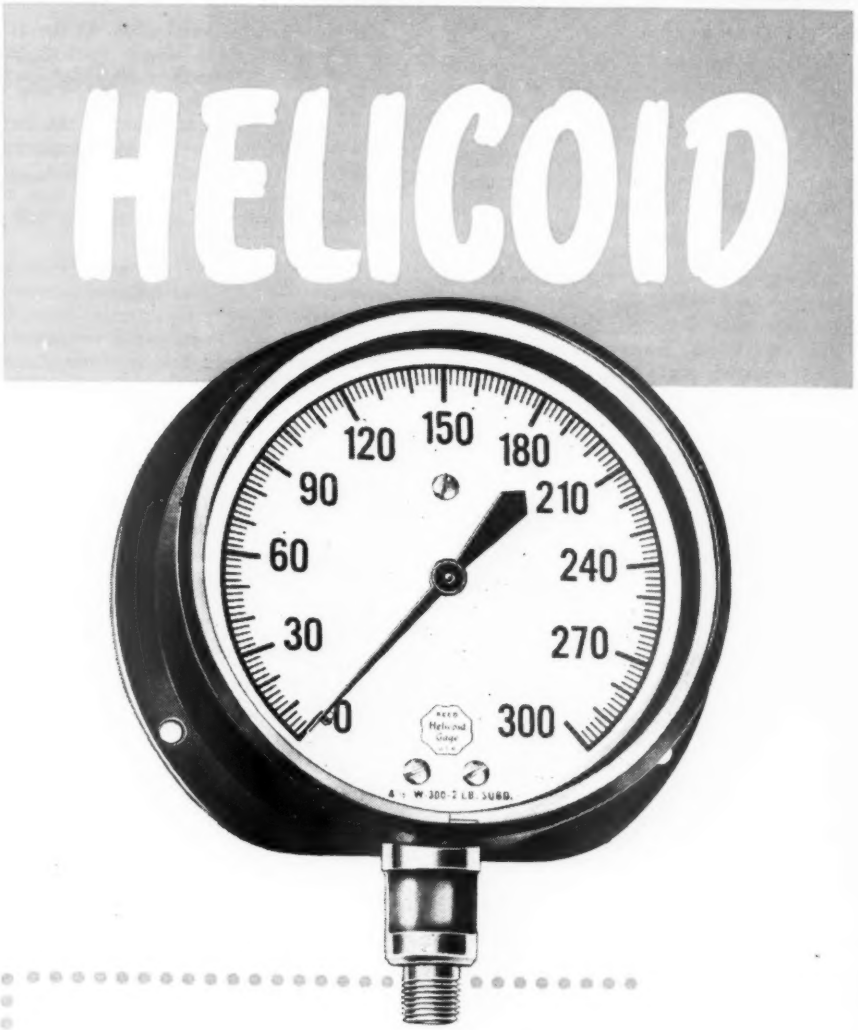
The Industrial Chemical Company, producer of the new type additive, explains that when Induco Fluid is added directly to diesel fuel it takes immediate chemical action against the sulphur, rosin, gum, and tar content of the average fuel oil, turns these into substances that will ignite efficiently upon injection. The result, as is well indicated by Rocky Mountain's remarkable record-making non-stop run, is an increase in horsepower as well as fuel economy and an extended period of trouble-free engine operation.

(13) Arc-welding electrode

The new Airco No. 387 all position arc-welding electrode for welding of mild steel provides an electrode of the E 6012 class with the following specific characteristics:

1. The bead is smooth and of proper contour.
2. Excellent operating characteristics are obtained on a-c or d-c.
3. A minimum of spatter is produced when used on either a-c or d-c.
4. Operates most satisfactorily in all positions; especially when welding vertically down.
5. A high degree of welding performance is maintained throughout the entire length of the electrode when high welding currents are used.
6. Exceptionally easy slag removal.
7. More inches of weld per electrode than most E 6012 class electrodes.

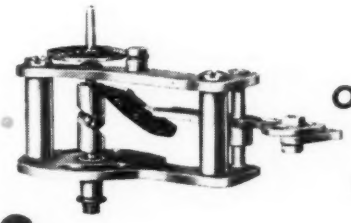
This electrode is available in 1/8 in., 5/32 in., 3/16 in., and 1/4 in. diam.



The name HELICOID has become synonymous with pressure gages of enduring accuracy.

Helicoid has pioneered in so many improvements in design and materials to make gages last longer, retain their accuracy and to withstand all kinds of severe service conditions that the industry has also been encouraged to make improvements that would not otherwise be made—all to the benefit of the user.

For better gage value, insist on HELICOID.



Only Helicoid Gages have the Helicoid Movement

ACCO

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE
Bridgeport 2, Connecticut

(14) Power slips

DeCo "Balanced" Power Slips feature a minimized number of working parts and speed in round trip operations. The DeLaney Company has run field tests involving many thousands of feet of drill pipe and casing without undue shock or strain on either.

The operating cylinders are fixed in their "Balanced" position by means of bracket pads welded directly to the rotary, which hold slips in a centered position with it during the entire round trip operation. Many otherwise necessary working parts in power slips have been eliminated by this feature, states the manufacturer. "Balanced" equipment weight distribution is maintained continuously.

No factors are more important in the operation of any slips than proper coordinated elevator, brake, and slip settings, for each depends on the other for maximum efficiency. The driller's coordinated operation of the DeCo slips and the drill pipe or casing necessarily means faster, smoother, less costly round trips, it is asserted. Of prime importance is the fact that the driller sets and disengages DeCo power slips. He has full control over the slip operation, affording the floor men safety from injury that can be sustained during the difficult and hazardous task of setting and disengaging hand slips. At the driller's position is a single foot control pedal that alternately raises and lowers the DeCo power slips.

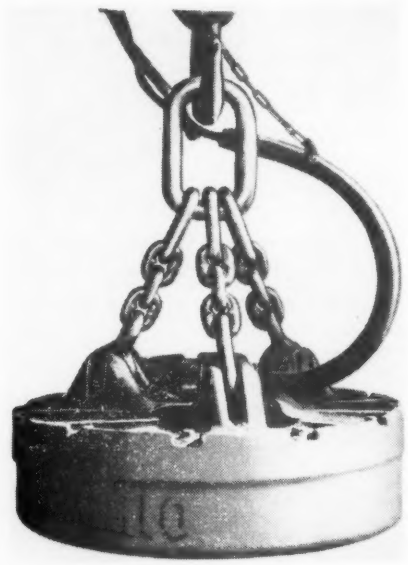
The main factor of safety in the DeCo power slips is the patented automatic safety valves, which prevent the operating slip pistons from going into the down position if at any time air failure should occur.

DeCo "Balanced" Power Slips are manufactured by the DeLaney Company to handle tubular equipment from 2⅜ in. to 7 in. The company is prepared to supply and install this equipment complete.

Driller has just let down a joint of pipe and applied elevator brake.

(15) T M level-lift

The S. G. Taylor Chain Company recently announced that it has taken over the patents on Caldwell Adjust-A-Leg Chain Sling and that the name of the product has been changed to T M Level-Lift. T M Level-Lift is a complete lifting assembly made up of an equalizing unit and one continuous Taylor Made alloy steel sling chain with an alloy steel hook on either end. The Taylor Made sling forms two legs of the chain, which can be adjusted in length according to the shape of the lift or the distribution of the weight of the lift. When the load is raised, the equalizing unit frictionally locks the chain into position to prevent shifting of the lift while being carried.



The unit is made in five standard sizes with capacities ranging from four to forty tons. The T M Level-Lift permits the safe handling of bulky material of odd sizes and shapes. It eliminates the necessity of carrying many different lengths of sling chains and the unsafe practice of kinking, twisting, and spiking sling chains. The unit can be used in pairs or in combination with standard slings for a two, three, or four point suspension.

(16) Tube cleaner

A powerful geared tube cleaner known as No. CC-325 has been developed by the Airetool Manufacturing Company for removing extremely bad scale in heat exchanger and condenser tubes ⅜ in. to 2½ in. ID.

This geared cleaner is one of three models of powerful outside mounted cleaners designed and recently put into production.

No. CC-325 is particularly effective where conditions require low speed and extreme power. The motor of this type operates up to a maximum of 800 rpm and will thoroughly clean tubes even though completely closed with scale. Various types of drills are available for use with this cleaner. The proper choice of drills may be made depending upon the scale condition encountered. A unique flushing system insures a cool drill while flushing out removed scale. As in other Airetool outside mounted cleaners, No. CC-325 has a control valve on the handle that gives the operator positive control. A muffler that eliminates noise without reducing the power is available for this cleaner.

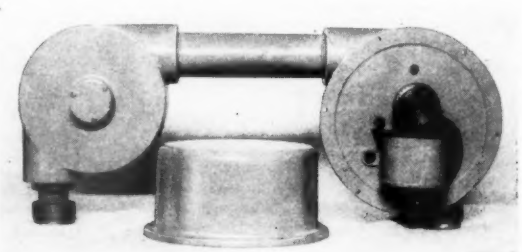
(17) Liquid level gauge

A new type of remote indicating liquid level gauge, manufactured by the Nelson Automatic Gauge Company, is shown in the accompanying illustrations.

The transmitter is equipped with an oil immersed rotary switch that transmits impulses to the receiver. The transmitter is not connected to tank through pipe connections but utilizes a stainless steel wire through packing glands. This method provides an air space between tank and transmitter, thus keeping gas in the tank and out of transmitter housing. It is especially effective where H_2S is encountered.

An automatic device connects the unit to battery operation upon a-c line failure.

A circuit for high and low level signal is provided. This circuit can be used also to start and stop motor-driven pumps at predetermined levels.



trade literature

PUBLICATIONS LISTED ARE SENT FREE UPON REQUEST

(18) Power pumps

Oil Well Supply Company has issued a new 28-page booklet, No. 6C-1047, "Oilwell"-Wilson-Snyder Power Pumps, descriptive of the "Oilwell"-Wilson-Snyder pumps for mud service, general service, and for waterflooding. This booklet, now available for distribution, is of particular interest because it describes many design features of this "Oilwell" machinery not yet generally known to the industry.

(19) Preventing reverse rotation

A new illustrated bulletin on the improved Falk Backstop is now available upon request. This 4-page bulletin, No. 10,080, provides complete, easy-to-read information on the construction and operating advantages of the Falk Backstop. The new Falk Backstop provides a positive method for preventing a reverse rotation on conveyor drives, elevator head shafts, windlasses, winches, and on all applications where reverse rotation should not occur. "Back-run" or reverse rotation in some machinery operations may cause serious damage to the machinery and the material being handled. In addition, expensive production delays may result. The gripping action of the Falk Backstop takes place at the precise moment that forward rotation ceases. It reduces the possibility of shock or strain to a minimum.

(20) "Easy Flow" pumps

The complete new line of Rex "Easy Flow" speed prime pumps is illustrated and described in Bulletin No. 47-12, published by Chain Belt Company. The Rex "Easy Flow" pump has a pump body that is press-formed of abrasion and corrosion-resistant steel plate for a smooth, fast easy flow of water into, through, and out of the pump. In addition, it has an air-peeler that is adjustable from outside the pump body and a replaceable wearing plate between the impeller and volute to give new-pump efficiency for the lifetime of the pump. It has a new self-lubricating seal to prevent air from entering around the impeller shaft and destroying the vacuum, a double-duty lifting bail, and an entirely new mounting, in which the motor, the heaviest part of the pump, is positioned directly over the wheels for greater ease of portability.

(21) Allowable working pressures

Tube Turns, Inc. has issued a new and enlarged edition of the booklet, "Allowable Working Pressures," which designers, fabricators, and users of industrial piping systems will find an important and time-saving reference source.

The booklet gives allowable working pressures for Tube-Turn welding fittings in five classes of piping. The tables are based upon the ASME Boiler Construction Code, 1946 edition, and the American Standard Code for Pressure Piping, ASA B31.1, 1942, as revised by supplement No. 2, ASA B31.1b, 1947.

(22) Wire rope handbook

The Wire Rope Institute, a national organization with a membership representing most of the country's wire rope manufacturers, has recently published an attractive, 2-color combination catalog and handbook for general distribution to wire rope users.

This new 119-page publication, "Wire Rope," prepared and edited by the Institute's technical committee, contains a wealth of useful information in the selecting, buying, and using of wire rope, along with data on fittings attachments, splicing, and other related subjects.

(23) Centrifugal blowers

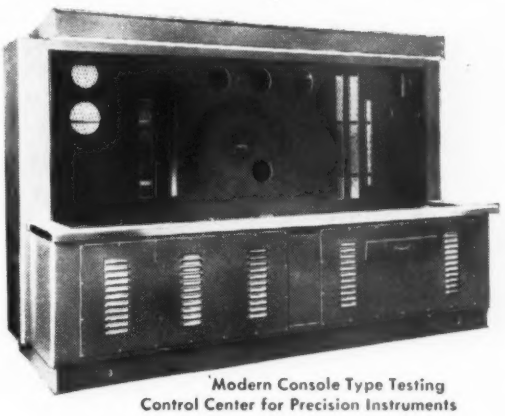
The blower department of Elliott Company has issued an 8-page bulletin, P-7, on its Type P single-stage centrifugal blowers using open type radial bladed impellers. Pictures show interior construction, packing box, and bearing details. Performance and blower shaft horsepower curves are included.

Quality AT A GLANCE

...in a FINE WATCH

...in a

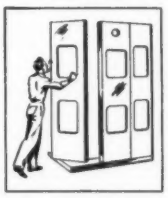
FALSTROM PANEL



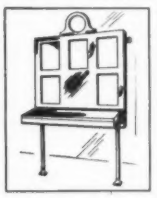
Modern Console Type Testing Control Center for Precision Instruments

A FINE panelboard does much more for the instruments on it than support them properly. Just as the scintillating case of a fine watch points to the worth of the precision movement within it—so the design, smooth lines and custom features of a Falstrom Panel indicate the outstanding superiority of the entire control assembly... *quality at a glance!* Write for illustrated bulletins S125 and S126.

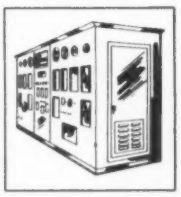
STRUCTURES FOR EVERY CONTROL REQUIREMENT



New Knocked-Down Cubicles



Control Panel with Monitor's Desk



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is a fast, safe, reliable and economical method for determining the amount of the dip and strike of the geological formation through which the hole is being drilled.

Designed for use in combination with the regular retractable wire line coring equipment now in use in the oil fields. Ordinary rig procedure is not disturbed. No special bits or drill collars are needed Oriented cores can be taken at any time when the operator is coring by the wire line method, without pulling the bit from the hole or changing the drill set-up in any way.

Thoroughly proved through extensive oil field use.

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(24) Plastic coating for corrosion

Of decided interest to oil men in all operational phases of the business is a brochure just released by the Amercoat Division of American Pipe and Construction Company, dealing in a very complete way with the control of corrosion through the application of plastic coatings. In this informative booklet many pertinent industry problems are cited in the production, storage, transportation, and refining departments; corrosion causes are defined; and means of avoiding deleterious effects are recommended.

The treatment opens with a full chapter on the protection of refinery equipment from such agents as acid sludge, ammonia, sulphur dioxide, caustic soda, hydrochloric, hydrofluoric, and sulphuric acids, in addition to the ordinary oxidants to which vulnerable metals are normally subject. It then discusses the producers' difficulties, taking up the protection of lease tankage from sour crudes; the rendering of drilling equipment immune to the action of sea water in offshore drilling, and to oil well brines in normal operations. Pipeliners also come in for a share of worthwhile information, and, indeed, anyone with a corrosion worry would do well to take a look at this exposition.

(25) Trucking with diesels

The latest issue of "*The Dependable Diesel*", a publication for users of diesel power, issued by the Cummins Engine Company, Inc., is now available. The current issue contains stories about diesel trucking in the southwestern United States, the use of diesel trucks underground by the Eagle-Picher Mining and Smelting Company, an account of the repowering of five motor cars by the Baltimore and Ohio Railroad, and other stories of diesel power applications.

(26) Flexible couplings

A new catalog on Baldwin-Rex roller chain flexible couplings has been released by the Baldwin-Duckworth Division of Chain Belt Company. The new book presents a comprehensive story of Baldwin-Rex couplings—their design, application, selection, and prices. To clarify intricate design and application features, cutaway, "explosion" photos, and simple drawings are used.

Diagrams of the five types of shaft misalignment are shown, and a group of charts make the selection and ordering of couplings an easy task.

(27) Oiling devices; sightfeed valves

Wm. W. Nugent and Company, Inc., has issued two new bulletins. No. 15 bulletin illustrates and describes profusely the Nugent telescopic oiling devices for reciprocating and revolving bearings. These oiling devices have a stationary oil supply with the regulating valve which is connected by anti-packed, oil-tight, dust-proof gravity or pressure telescopic tubes to the moving bearing or pin. The bulletin illustrates a great many applications.

Bulletin No. 16 profusely illustrates and describes the Nugent sightfeed valves, sightflow fittings, and compression union threadless pipe fittings.

(28) Stainless steel piping

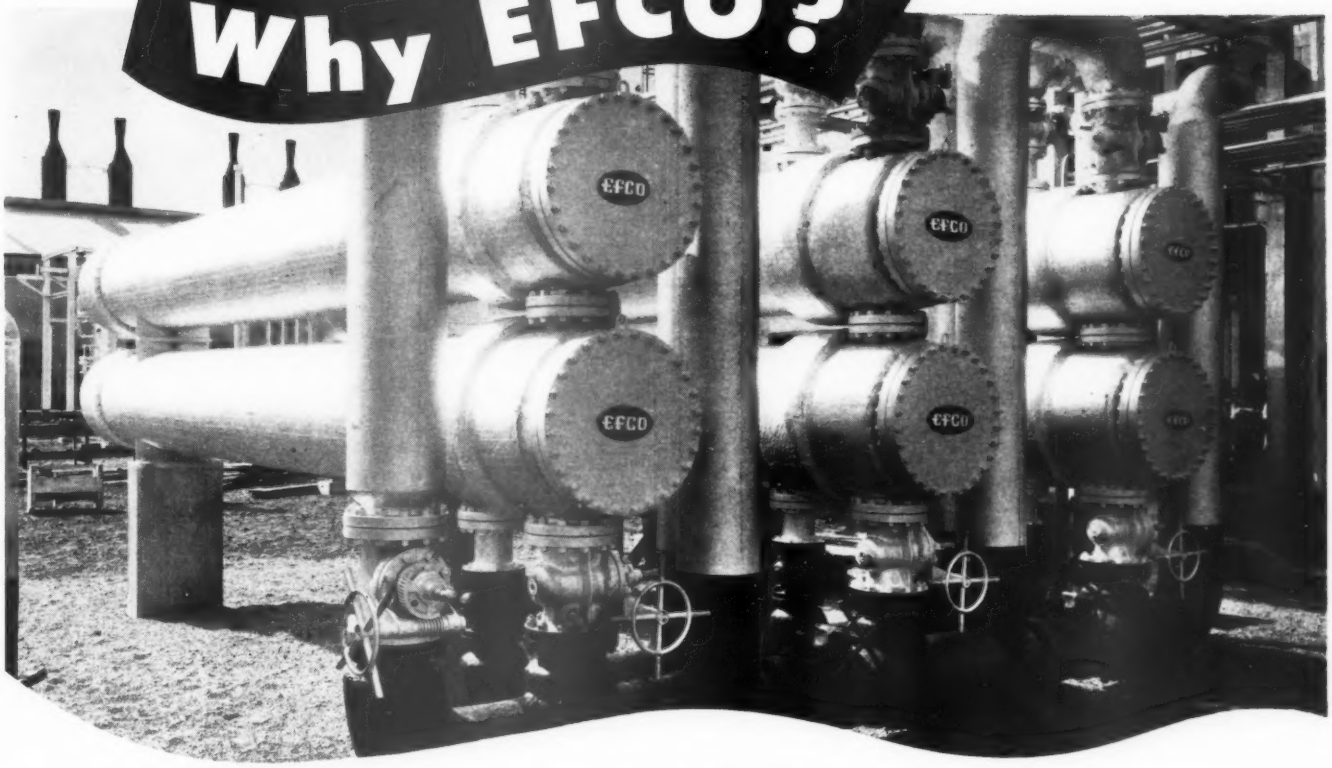
A new booklet, "Stainless Steel Piping—Why and Where to Use It," deals authoritatively with its subject and makes a welcome addition to the reference libraries of piping engineers. It was written by J. D. Mattimore, chief engineer of the product and research division of Tube Turns, Inc. The booklet also contains numerous tables and illustrations.

(29) Chemical resistant coatings

Rust-Oleum Corporation has issued a new descriptive bulletin on chemical resistant coatings now in production by Rust-Oleum. Designed as a coating for service in the presence of acid or alkali fumes, condensates, moisture vapors, alcohol fumes, greases and oils, these new coatings are fortified with rubber to resist chemical conditions that are the major cause of rust in many types of industrial plants.

Complete, easy-to-understand data is given on coverage, thinning, accumulated condensation, heat resistance and interior of metal storage tanks. Actual instances of the coatings in use are shown in photographs of plants whose equipment includes tanks and pipes for the storage and use of chemical products. Much of the bulletin's information on the use of Rust-Oleum's chemical resistant coatings is new since it details how and why

Why EFCO?



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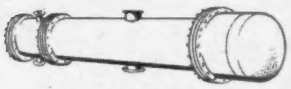
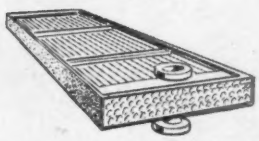


CONDENSERS



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With the installation of EFCO heat transfer units in your plant, you will be sure of getting *guaranteed performance* with the extra advantages of low maintenance cost, high operating efficiency, long life and freedom from leaks.

Talk over your heat transfer problems with an EFCO engineer. He will tell you about EFCO installations that have successfully solved problems similar to yours and explain how EFCO equipment will give you the performance you want.

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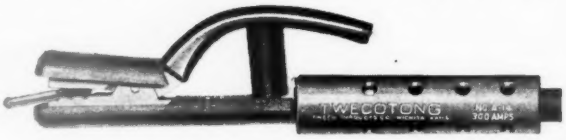
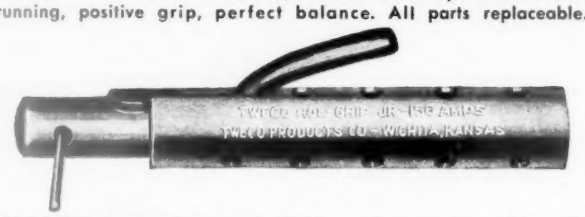
EFCO HEAT TRANSFER EQUIPMENT

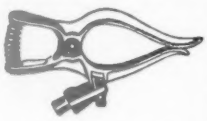
WELD WITH TWECO



"TWECOTONG" Insulated Electrode Holders feature simplicity of design and operation. Laminated Glass Cloth Insulation is almost indestructible. Made in 200, 250, 300 and 500 ampere sizes. Cool running, positive grip, perfect balance. All parts replaceable.



"Hol-Grip" Insulated Electrode Holders grip rods at positive 45° and 90° positions. Easy one hand operation. Made in 150, 200, 300 and 500 ampere models. Light weight, cool running, simple operation, low cost.



Redhead Ground Clamps come in Midget 125 amp., Jr. 300 amp. and Sr. 500 amp. models made of high copper alloy. Features insulated spring, clamp cable connector. Provides a portable, rugged, efficient, low cost ground.

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HERE are 28 pages of job-tested maintenance cleaning procedures in the production, refining and distributing divisions of the industry.

Based on operating records of both large and small petroleum organizations, this Digest contains 88 shortcuts to economy in cleaning, paint-stripping, descaling and related procedures. Write TODAY! No obligation.

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the product resists chemical conditions where general weathering or constant expansion and contraction are not primary causes of rust.

Listed on the bulletin's back page is a convenient 9-point check list that outlines directions for applications of the chemical resistant coatings on both rusted and clean metal.

(30) Unit pumper

Bulletin No. 334 describes and profusely illustrates three styles of National Supply Company Type D-9 unit pumpers for medium pumping requirements, with approximate API walking beam ratings of 9000 lb and API peak torque ratings of 40,000 in.-lb. The bulletin features serviceability achieved by engineering design, throughout, using explosion views of structural members and mechanisms for illustration. Also included are dimensioned assembly drawings and comprehensive specifications.

(31) Screw type Simplex jacks

Templeton, Kenly and Company, manufacturers of lever, screw, and hydraulic jacks for use by construction, industrial, chemical, and petroleum fields, has issued an engineering data bulletin on its screw type Simplex jacks for supporting and leveling tanks for outside applications.

Designed to facilitate industrial plant installation of horizontal and vertical storage tanks and filter and softener tanks, this series of tank jacks is illustrated in actual use in the bulletin "Tank 48." Screw adjustment produces exact leveling and gravity flow, irrespective of variations in the floor. Vibration or pounding in the tank will not disturb the jack level. The tank jack is readily movable to any other location.

(32) Seeing pH of dehydrator water

A newly revised bulletin, issued by Leeds and Northrup Company, features equipment that is said to enable refinery operators to "see" the pH of dehydrator water simply by glancing at the indicating scale of a Micromax recorder. Operator can then regulate the flow of ammonia or caustic for correct neutralization in the tower, or, by examining the chart record drawn by the recorder, he can see the trend of pH during the past hour, day, or week. This publication describes and illustrates the L&N glass electrode assembly (now available with a transparent flow chamber), which constantly detects the pH of a continuously-flowing sample of water, while the Micromax recorder indicates and records the result.

(33) Oil burning system

Peabody Engineering Corporation has reprinted its "Constant Differential Oil Burning System Bulletin No. 109." General distribution on this has long been restricted but copies of the new bulletin No. 109-A are now available. Completely diagrammed and charted, Bulletin No. 109-A not only explains how the constant differential system operates but also illustrates, in cut-away fashion, the atomizer itself with complete explanation of how extreme fluctuating loads are handled under positive regulation with full flame control.

(34) Properties of plastics

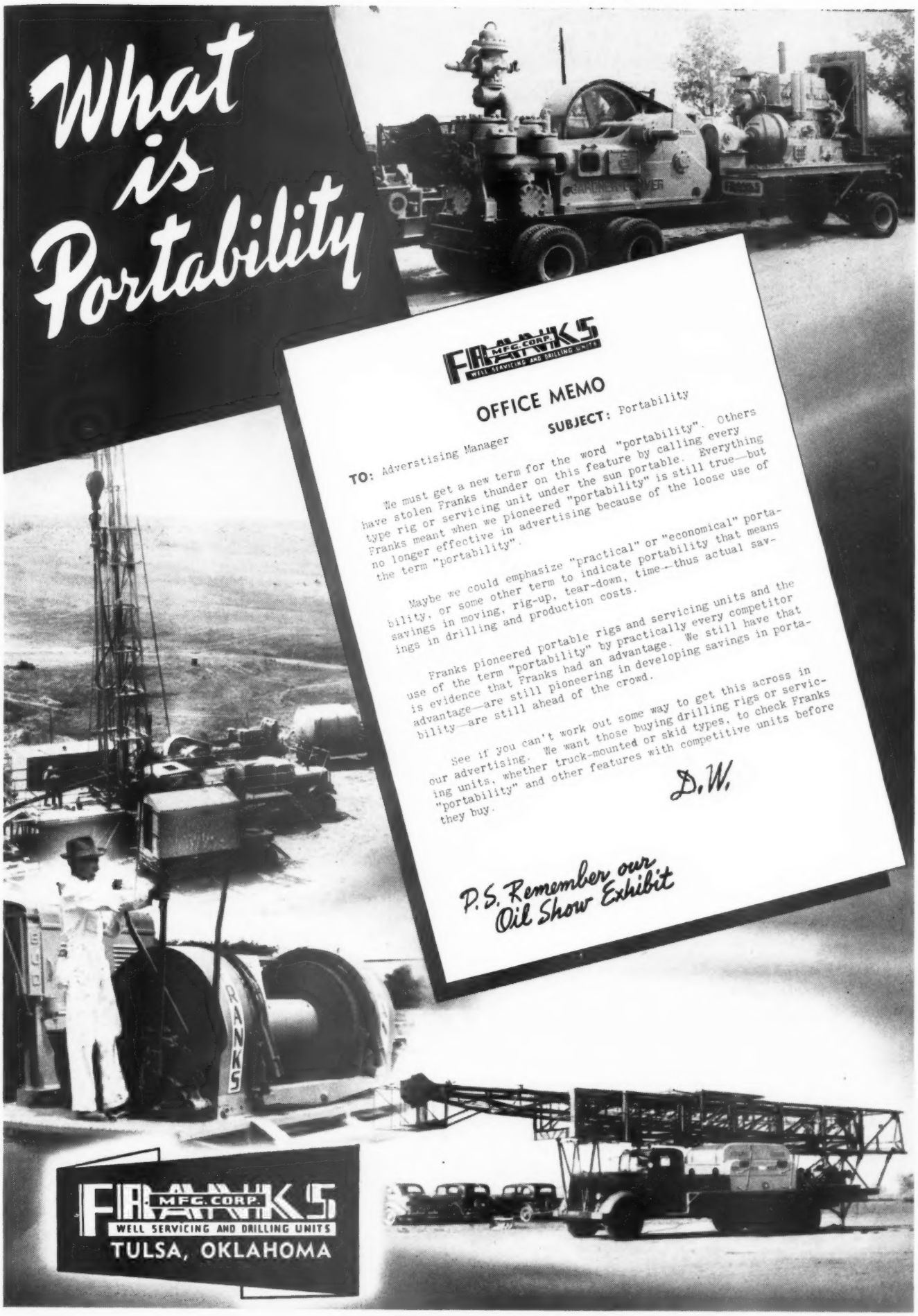
The Chemical Division of Koppers Company, Inc., has issued a chart that presents in easily readable form the "Properties of 17 Popular Modern Rigid Plastics". The chart measures 17 by 22 in., and is arranged to assure quick and convenient information on the relative degree of a particular property as possessed by the different rigid plastics.

(35) Dual-fuel attachment

A 4-page pamphlet announcing the dual-fuel attachment for the "Caterpillar" D13000 diesel engine has been released by Caterpillar Tractor Company. The pamphlet underscores the versatility of the engine when the attachment is added and points up the economic operation of the entire unit when utilizing natural gas. Speed of installation and ease of operation of the attachment are emphasized in the publication.

(36) Foundry cupola blowers

Bulletin 120-123-B11, covering foundry cupola blowers of both the rotary positive and centrifugal types, has been issued by Roots-Connersville Blower Corporation. This is an 8-page, 2-color booklet. On page 2 is found a table that gives the


What is Portability
FRANKS MFG. CORP.
WELL SERVICING AND DRILLING UNITS
OFFICE MEMO
TO: Adverstising Manager
SUBJECT: Portability
We must get a new term for the word "portability". Others have stolen Franks thunder on this feature by calling every type rig or servicing unit under the sun portable. Everything Franks meant when we pioneered "portability" is still true—but no longer effective in advertising because of the loose use of the term "portability".
Maybe we could emphasize "practical" or "economical" portability, or some other term to indicate portability that means savings in moving, rig-up, tear-down, time—thus actual savings in drilling and production costs.
Franks pioneered portable rigs and servicing units and the use of the term "portability" by practically every competitor is evidence that Franks had an advantage. We still have that advantage—are still pioneering in developing savings in portability—are still ahead of the crowd.
See if you can't work out some way to get this across in our advertising. We want those buying drilling rigs or servicing units, whether truck-mounted or skid types, to check Franks "portability" and other features with competitive units before they buy.
D.W.
P.S. Remember our Oil Show Exhibit
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FRANKS MFG. CORP.
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MORE QUALITY...
MORE SERVICE...

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FORGED STEEL Screwed and Socket Welding FITTINGS
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- *Full Range of Sizes from ⅛ inch through 4 inches*
- *Pressure Ratings from 2000 through 6000 pounds*
- *Carbon, Stainless and Alloy Steels*

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melting rate, with air volume and pressure required, for standard size cupolas. Below this is another table giving performance data on the sizes and types of R-C blowers that are recommended for use on foundry cupolas. A general discussion of "R-C dual-ability" follows on page 3. Pages 4 and 5 are devoted to a more detailed consideration of the rotary positive type. Pages 6 and 7 are devoted to centrifugal blowers of the 'OI' and 'OIB' types. On the back cover, there is a discussion of the application of air-weight controls to the R-C blowers.

(37) Keeping equipment on the job

New welding products bulletin 1047-W, released by the American Manganese Steel Division of American Brake Shoe Company, is a complete treatise on how to keep equipment of all types operating and producing through Amsco conservation welding. Twenty-eight pages of photographs, drawings, and descriptions explain the low-cost method of keeping hard-to-get parts out of the scrap pile by repairing, rebuilding, reclaiming, and hardsurfacing with Amsco welding rods and electrodes.

(38) Relief from bearing wear

A new booklet entitled "Relief From Bearing Wear Grief" reveals a new answer to some old problems of power transmission loss and prematurely worn bearings. This booklet reveals how many plants are preventing the destructive waste of downtime caused by bearing failure, shaft failure, and damaged equipment through the improper coupling of rotating shafts.

This booklet describes the functions of flexible couplings. A thorough explanation and analysis is given to the principles by which couplings operate and their importance in relationship to the equipment they connect.

The booklet is published by the American Flexible Coupling Company, division of the J. A. Zurn Manufacturing Company.

(39) Three-channel carrier telephone

Lenkurt Type 32 carrier telephone systems are described in Bulletin 62A, published by Lenkurt Electric Company. An exhaustive engineering report on the system, the 68-page bulletin covers frequency allocations for carrier telephone, and continues with descriptions of the terminals, repeaters, pilot regulators, and auxiliary units that make up the system.

(40) New crawler tractor

A colorful, pictorial book on the new TD-24 crawler tractor is now available from International Harvester. Designated by the company as Form No. A-34-LL, the book has a 4-color cover featuring both the TD-24 and "Planet Power Steering", the latter being a new design development in the crawler tractor field.

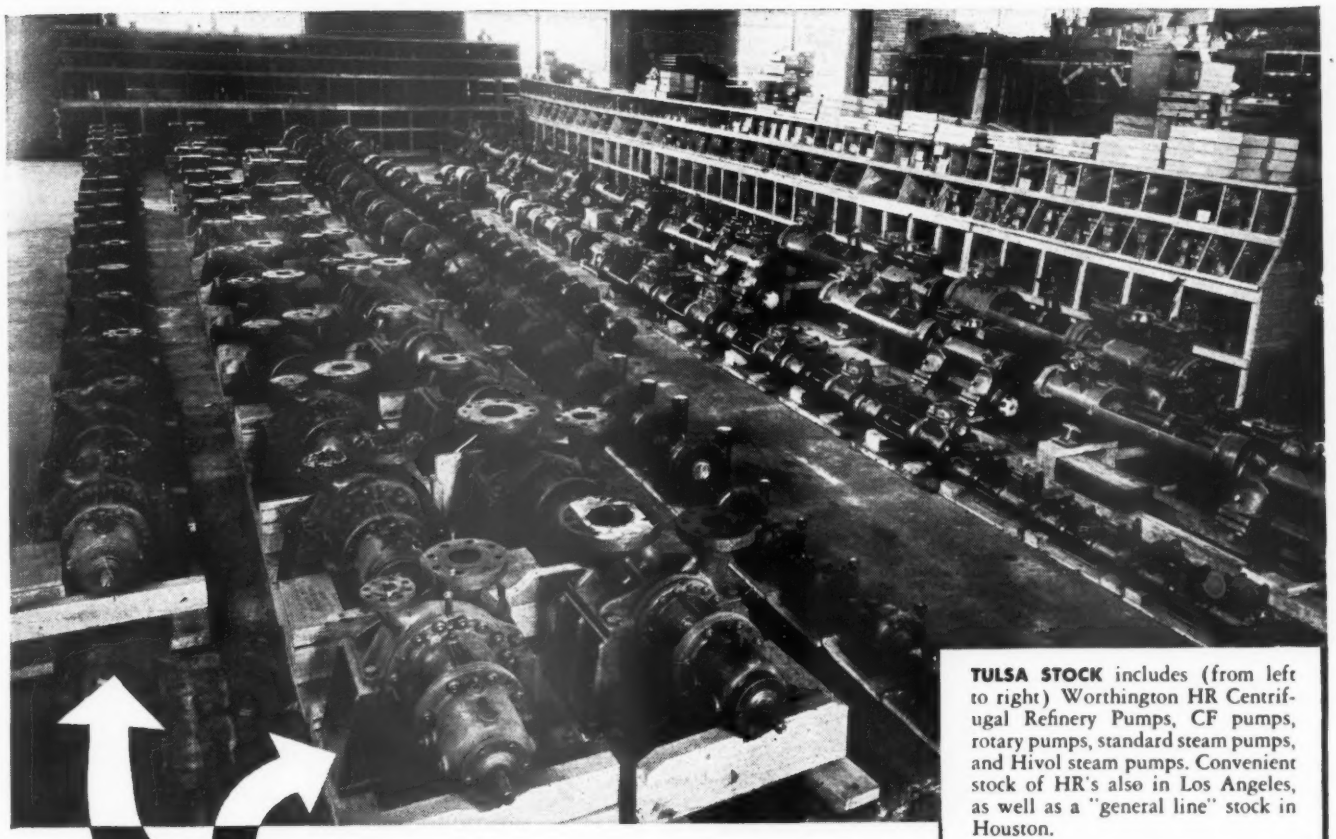
This book uses the "picture story" techniques employed in modern magazine layout. More than 50 sectional views, line drawings and photographs—many in two colors—give a clear portrayal of the working functions of all important parts in the TD-24. Action photographs of on-the-job scenes are printed in duo-tone.

(41) Oil well casing

Bulletin 352 gives eight reasons for using Extreme Line Casing, Spang-Chalfant's solution of the problems encountered in completing the deepest oil wells. Another feature is casing clearance tables in three colors to distinguish extreme line casing dimensions from those of API casing, and clearances between standard bits and inside of casing from clearances between couplings or joint OD's and open holes. A quick design chart for 7-in. OD casing combination strings is included also, as well as a tabulation of Extreme Line Casing weights and sizes.

(42) Pipe line booklet

Recently issued by Pacific Pipeline and Engineers, Ltd., is an interesting booklet on pipe line construction, engineering, and maintenance. Profusely illustrated, the booklet opens with pictures of the branch offices, jumps to spot shots of some of the typical jobs tackled by the organization, and, incidentally, these jobs, of infinite variety, are scattered all over the United States and into foreign lands. There follows an imposing display of the facilities of the company and a list of its clients. Technical data is then given on such matters as the weight of oxy-acetylene and electric welding rod required for circumferential pipe welds of various wall thickness and various OD's; dimensions and weights of welded and stainless steel pipe, and material requirement for joints on cast-iron pipe. Another section deals with pipe reclamation and reconditioning.



TULSA STOCK includes (from left to right) Worthington HR Centrifugal Refinery Pumps, CF pumps, rotary pumps, standard steam pumps, and Hivol steam pumps. Convenient stock of HR's also in Los Angeles, as well as a "general line" stock in Houston.

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HR Centrifugal Refinery Pumps

This is the pump that is standard equipment in leading refineries the world over—and Worthington has plenty of them.

Because it is "made to order" for refinery processing, *right* in every single detail, the HR Centrifugal Pump is carried in stock.

With adequate stocks of the hard-working HR on hand—not only in Tulsa, but also in Los Angeles—Worthington can offer fast, efficient service on emergency replacement or changeover requirements.

We invite you to take advantage of this opportunity to secure an HR Centrifugal Pump right from stock.

For further information proving *there's more worth in Worthington,* contact our nearest District Office. Or write to Worthington Pump and Machinery Corporation, Centrifugal Pump Division, Harrison, N. J.

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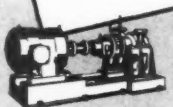
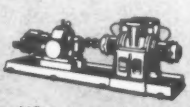
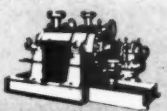


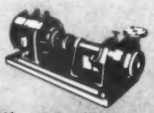
Types HR and HB. Twenty sizes. Capacities up to 1800 g.p.m. Developed heads up to 900 ft. Proper selection of material permits use for temperatures far below zero to 800°F., for pressures from high vacuum to 750 lb. per sq. in. gauge.



Type HD. Hydraulically-balanced, double-suction impeller handles boiling liquids with low submergence. Capacities range from 600 to 3200 g.p.m. at heads up to 700 ft., temperatures up to 850°F., pressures up to 550 lb.



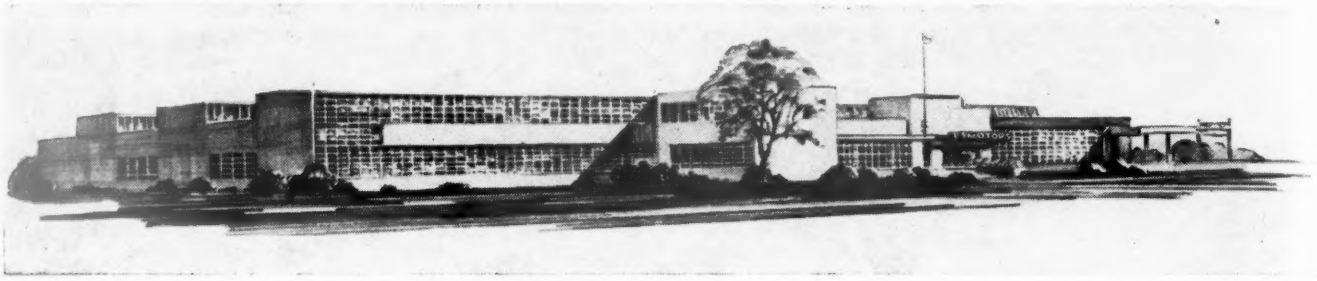
Type WH. High-pressure, high-temperature, centrifugal hot-charge pumps. Twelve distinct points of superiority, based on years of experience building pumps for high pressures and temperatures. Capacities to 2000 g.p.m., heads to 5000 ft.



Type HL. Several construction arrangements permit flexibility in application. Designed for temperatures up to 225°F., or higher with water-jacketed stuffing box. Capacities up to 1600 g.p.m., heads to 500 ft.

U. S. Motors doubles size of Milford Plant

The largest expansion in the history of U. S. Electrical Motors, Inc., is taking shape in Milford, Connecticut, where the company's Atlantic plant is now being more than doubled in size. The original plant was constructed in 1939 and was expected to be adequate for at least two decades; however, the substantial increase in business and the continued postwar demand for the various types of electrical equipment made by U. S. Motors has necessitated this extensive expansion program, it is announced.



With the completion of the expansion program, U. S. Motors will manufacture motors used east of the Mississippi River in the Milford plant. Construction is now under way and it is expected that the enlarged facilities will be completed by next June.

The plant will be steel construction monitor type, complete with latest type lighting, cranes, conveyors, and machine tools, and with the new foundry and auxiliary buildings will add over 75,000 sq ft area. The new buildings and former plant are all on the company's original 57-acre site.

General sales manager

Since the Penberthy Injector Company became a subsidiary of the Buffalo Bolt Company, the products, policies, and personnel have continued unchanged with only one important exception in personnel. Fred E. Ruebelmann was appointed general sales manager to succeed A. D. Thomas who resigned. Ruebelmann has been a member of the Penberthy organization for more than 36 years, most recently as supervisor of sales.

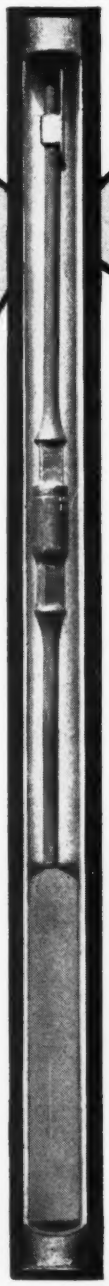
F. E. Ruebelmann

Made sales engineer

Charles M. Howell has been appointed petroleum sales engineer for the West Coast, according to an announcement by V. C. Genn, general sales manager of the Detroit Diesel Engine Division, General Motors Corporation. Howell will establish headquarters in California but operate out of the company's petroleum industry office at Tulsa, Oklahoma, under the direction of Arch F. Campbell. Howell came to Detroit Diesel in January of this year, directly from the Bethlehem Supply Company of California.

Chas. M. Howell

HUBER PARAFFIN SCRAPERS



MAKE YOUR SUCKER RODS YOUR PARAFFIN SCRAPER

Put an end to paraffin accumulation and the cost of steaming out or "passing rods" to free your wells of paraffin.

Huber Scrapers actually make the sucker rod string your paraffin removing agent. Attached to the rods, they constantly scrape the paraffin from the tubing wall as the rods reciprocate and rotate. The scrapers clear the tubing wall by a fraction of an inch so that paraffin is wiped off and pumped out before it can accumulate.

Equip your sucker rods with Huber Scrapers and stop costly paraffin troubles.

- they scrape while they rotate and reciprocate.
- require no servicing or attention.
- soon pay for themselves by saving work-over costs.
- hundreds of users report outstanding success of their operation.

ROTATING HEAD

This patented head automatically rotates the rod string a fraction of a turn on each stroke so that the scrapers wipe the wall free of paraffin.

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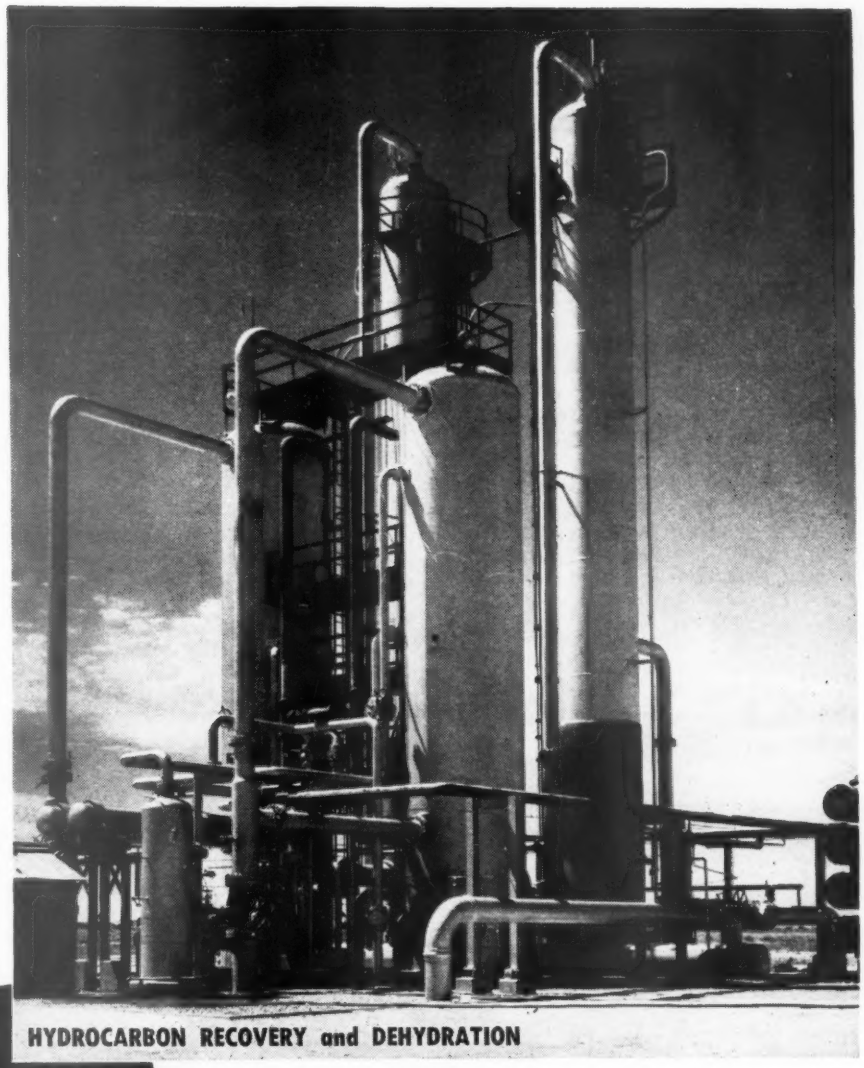
Pritchard gas engineering services

Compressor stations
and additions
Pressure maintenance units
Dehydration
Desulphurization
Conditioning and treating
L.P.G. installations
Hydrocarbon dew point
control plants
Cooling and heat transfer
Removal of entrained
liquids and dust



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● **A. W. Ambrose,** president of Cities Service Oil Company, Bartlesville, Oklahoma, was elected a director of Cities Service Company to succeed the late **B. G. Tremaine** of Cleveland, Ohio. Ambrose has been associated with Cities Service Company since 1923.

● **John Preston Sutton,** for many years an executive of The Ohio Oil Company, died of a heart attack recently at his home in Findlay, Ohio. He was 71 years old and had been ill for the last three weeks.

For 38 years, Sutton was connected with The Ohio Oil Company and at the time of his retirement from active service January 1, 1942, he was serving in the capacity of industrial relations manager and assistant treasurer.

● **C. B. Carter,** division engineer, National Supply Export Corporation, New York, took part recently in the French government's extensive new oil exploratory program by assisting with their first installations of drilling rigs. Before his recent return he also made business visits in several European countries. Carter is well known in the Gulf Coast and Mid-Continent areas where he was associated with National Supply's stores and also the company's Plant Products Division at Houston. He also spent considerable time in the Toledo, Ohio, plant before joining the New York office more than a year ago.

● **John T. Oxley,** of Tulsa, Oklahoma, has been elected president of the recently organized Texas Natural Gasoline Corporation, an affiliate of Edwin B. Cox & Jake L. Hamon of Dallas, according to an announcement made by Jake L. Hamon and Edwin L. Cox. Until his resignation to accept the presidency of the new corporation, Oxley was secretary and assistant treasurer of Warren Petroleum Corporation of Tulsa, and manager of its gas division.

John T. Oxley

The Texas Natural Gasoline Corp. was organized, according to Hamon and Cox, to permit Cox & Hamon to become more actively engaged in the gas and natural gasoline phases of the petroleum industry.

Oxley is a native Oklahoman. His entire business career of 21 years has been spent with two corporations in the gas and gasoline branches of the petroleum industry. He was employed first by Amerada Petroleum Corporation in its production and revenue department in 1927. He was assistant manager of that department when he joined Warren Petroleum Corporation in 1935 at the time that corporation acquired the entire natural gasoline department of Amerada.

● **E. H. Horstman** and **Hans P. Dahlstrand** have been named respectively chief engineer and director of engineering of the Allis-Chalmers steam turbine department. Horstman, formerly assistant chief engineer of the Allis-Chalmers steam turbine department, assumes complete charge of steam turbine engineering. Dahlstrand has been associated with Allis-Chalmers since 1904, and has held the positions of engineer-in-charge, chief engineer, and more recently consulting engineer of the company's steam turbine department.

● **Dr. Harold Naidus,** after several years of industrial experience with high polymers as senior chemist for Publicker Industries, has joined the research staff of the American Polymer Corporation, Peabody, Massachusetts. He will do research and development work in high polymers for application to the adhesive, coating, and textile industries in his new post.

● **Howard H. Hinson,** of Amarillo, Texas, has been appointed chief engineer of Continental Oil Company's production research section, it is announced by W. C. MacMillan, vice president in charge of production, Ponca City, Oklahoma. In naming the Amarillo man to head up its production research, Continental announced an expansion program in this field, with other personnel to be added as they become available.

H. H. Hinson

Hinson, formerly assistant supervising engineer of the U. S. Bureau of Mines' helium plants at Amarillo, assumed his new position this month. With the Bureau of Mines' helium plants for 12 years, Hinson had supervised research in reservoir engineering and natural gas and had charge of all government-owned gas fields and pipe lines supplying gas to helium plants.

● **Fay Brainard** assumed the newly created position of special assistant to **Eugene Caldwell,** general manager of the Hyster Company, Portland, Oregon, on March 1. Brainard's new duties will be expediting projects in methods, inventory control, and similar fields. He has been plant engineer of the Portland plant since joining Hyster in 1942. He received his mechanical engineering degree from Oregon State College in 1941.

Svante Eikrem will assume the plant engineer position. He also received his mechanical engineering degree from Oregon State College in 1941. Since joining the company in 1943 he has worked on assembly line layout and on tool design in the Portland plant.

● **J. J. Zorichak,** formerly chairman of the Rangely Engineering Committee, Rangely, Colorado, has been appointed to the staff of the Division of Production of the American Petroleum Institute, Dallas, Texas, it was announced by Division Director C. A. Young. Zorichak will assist in administering the engineering and training activities of the division. He has had wide experience in drilling and production methods, including modern methods of reservoir control. He is a graduate of Pennsylvania State College and is a member of numerous technical societies and organizations. He is past president of the Rocky Mountain Association of Petroleum Geologists.

J. J. Zorichak

● **Sidney S. Lawrence,** for 18 years sales manager of Shell Chemical Corporation, has retired. Lawrence's career with Shell Chemical began while plans for the company's first plant were still in the blueprint stage. He helped choose the plant site and was sales manager when operations began in 1931 with the production of ammonia and ammonium sulphate.

The position of sales manager of Shell Chemical's Western Division will be filled by **Barclay K. Read,** formerly assistant sales manager.

● **George E. Grimshaw,** manager, industrial insulation department, Johns-Manville Corporation, will retire from the company on April 1 to establish himself as consultant on industrial insulation. Grimshaw, in his 32-year association with Johns-Manville, has spent eight years in both Pittsburgh and Cleveland and for the last 16 years has made his headquarters in the company's New York office. In his new venture, Grimshaw will specialize as industrial insulation consultant for the oil, steel, and chemical industries. His offices will be in New York City.

● **Wilmer H. Cordes,** manager, market development division of American Steel and Wire Company, has assumed the added duties of manager of the advertising division of that United States Steel subsidiary. Cordes this year will celebrate his 35th anniversary with American Steel and Wire, having first been employed as a messenger in the mailing department at Chicago in August, 1913. Within three months he was transferred to the advertising department and worked his way up through the ranks, being appointed manager of advertising in December, 1928. He subsequently held a number of other positions before being named manager, market development division, January, 1947.

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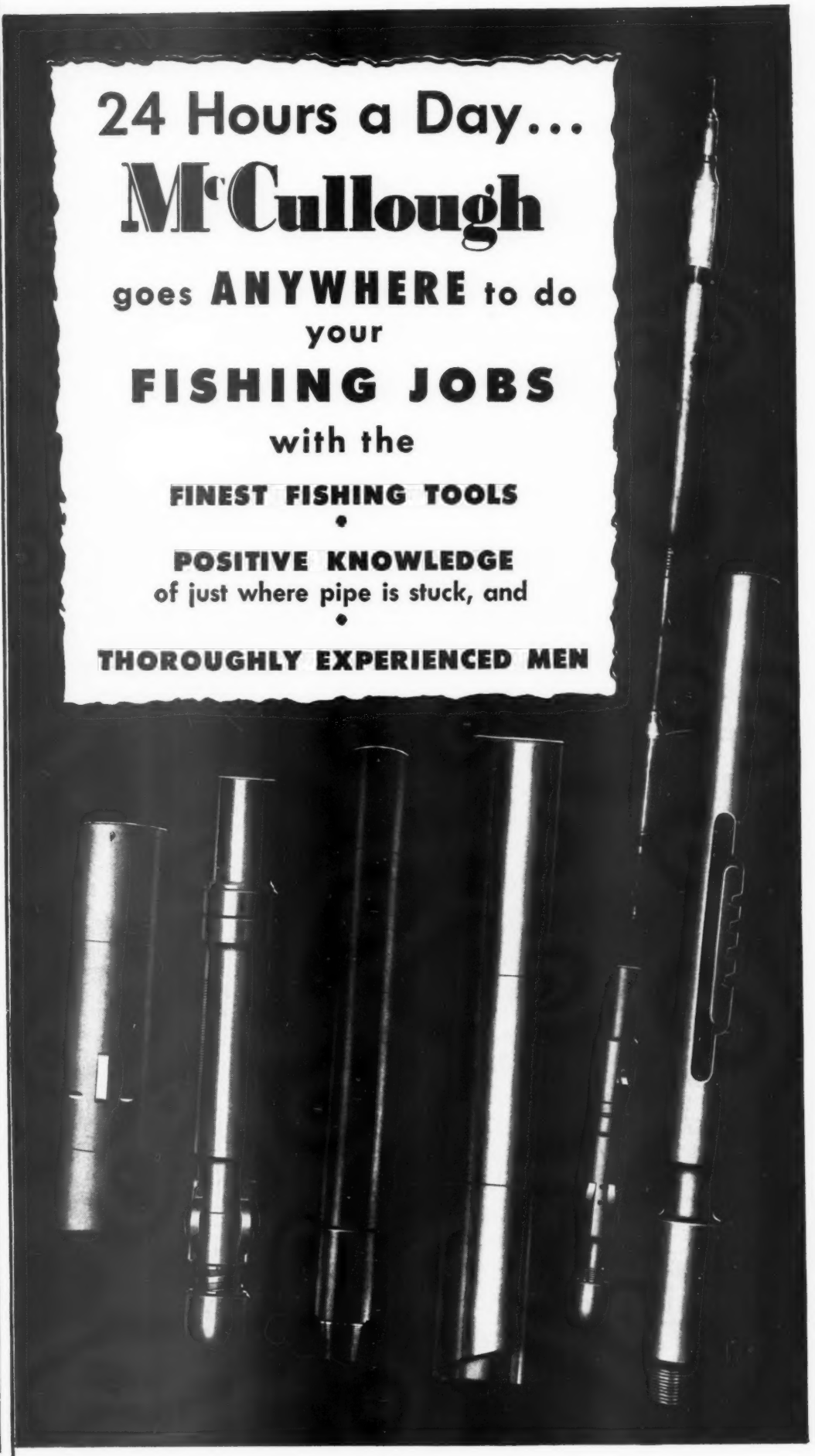

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● **Edith J. Dichter,** manager of *The Petroleum Times,* London, England, visited in the oil centers of the United States this month. She made arrangements for a booth at the International Oil Exposition at Tulsa, Oklahoma, May 15-22.

● **Roy B. Jones** died February 29 in Wichita Falls, Texas. He was 65 years of age. Moving from Illinois to Cushing, Oklahoma, in 1911, he became general manager of the Colonial Refinery. He was also manager of Panhandle Producing and Refining Company.

● **Harry D. Campbell** has joined Franco Western Oil Company as production engineer. He has previously been with Union Oil Company and Stanolind.

● **H. G. Abadie** has resigned as California division petroleum engineer for the Union Pacific Railway Company, Oil Development Department, Los Angeles, to assume the duties of senior production engineer for Long Beach Oil Development Company, Long Beach. Prior to employment with Union Pacific he was chief petroleum engineer for the Kettleman North Dome Association in the Kettleman North Dome field.

● **Dana S. Mellett,** chief engineer of the Trenton, Michigan, refinery of the Socony-Vacuum Oil Company, Inc., has been appointed vice president of the Mediterranean Refining Company. **E. A. Wilson** has been appointed chief engineer to succeed Mellett.

● **Floyd L. Martin** has been elevated to executive vice president of Sunray Oil Corporation by the company's board of directors. Martin will continue his responsibility as vice president directing the company's refining and sales division. C. H. Wright, president of Sunray, announced. He became a vice president of the company in 1935, and a member of the Sunray board of directors in 1941. Martin came to Oklahoma from West Virginia with the oil boom of 1916. Having served a refining apprenticeship in Oklahoma at Jennings, Allen, Sand Springs, Tulsa, and Ponca City, Martin joined Sunray in 1930 to operate the company's Allen, Oklahoma, refinery acquired from the former Homaokla Oil Company.

F. L. Martin

● **John Dew** has been appointed to the Aluminum Company of America fellowship in the School of Chemical Engineering, University of Oklahoma, Norman. He is working toward a master's degree and his research pertains to the study of the adiabatic dehydration of natural gas over activated alumina.

● **Wheeler G. Lovell,** for the last 21 years assistant head of the Organic Chemistry Department of the General Motors Research Laboratories, has joined the Ethyl Corporation Research Laboratories in Detroit as an associate director of research in the basic combustion field.

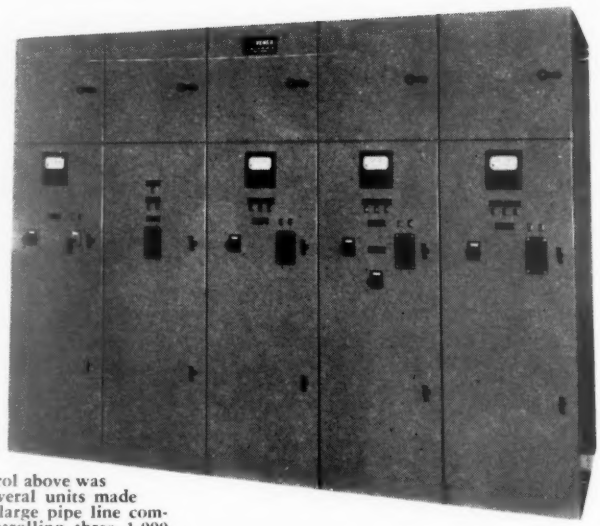
Lovell is a native of Mason City, Iowa. He obtained his chemical engineering degree at Massachusetts Institute of Technology in 1924, two years after his graduation from Harvard University as a chemistry major.

After a short period as a dye chemist with the National Aniline Chemical Company in Buffalo, New York, he joined the General Motors Research Corporation in Moraine City, Ohio, in 1924. He went to Detroit the following year, when the General Motors research organization was transferred to that city. Lovell became assistant head of the Organic Chemistry Department (then the Fuel Division) in 1927, serving with T. A. Boyd, who was a co-worker of the late Thomas Midgley, Jr., in the research program in which the antiknock properties of tetraethyl lead were discovered.

● **John W. Nabb** has been appointed manager of the Oil Well Supply Company store at Mirando City, Texas, it is announced by Paul H. Shepherd, manager of this U. S. Steel subsidiary Gulf Coast division. Nabb, who served with the U. S. Marine Corps in World War II, joined "Oilwell" in January, 1946, as storeman in the company's Alice, Texas, store, the position he leaves for the new appointment.

A native of Kansas City, Missouri, where he completed high school, Nabb attended Kemper Military Academy and the University of Kansas.

Explosion proof
MOTOR CONTROL
for pipe line stations



The Control above was one of several units made up for a large pipe line company, controlling three 1,000 H.P. Electric Motors.

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ELI Announces Improved B.H.P. Gauge

Greater Accuracy, More Ruggedness Built Into ELI-Manufactured Humble-Type Subsurface Pressure Gauge

Greater accuracy of records because of reduced friction has been attained by ELI engineers in developing the new "O" ring packing in the stuffing box, through which the pressure piston travels to the drum chart, on the improved bottom-hole pressure gauge. By chromium-plating this piston, friction has been further reduced and longer wear assurred. Accuracy proved and guaranteed for this instrument is one-quarter of one percent.

A new clock is available that will stand more abuse, delivers more power and has less internal friction. Its performance promises to set new standards for this type of instrument.

A new clock oil has been developed which is stable to 300° F and eliminates the necessity of re-oiling the clock in the field. The oil assures longer life of the clock, since forgetfulness in lubrication no longer affects its operation, and excessive oiling is prevented.

Uniform and accurate readings over long periods are now possible due to the especially-treated helical spring, which acts against pressure on the piston. Hysteresis has been reduced to give excellent repeatability. This spring is pre-loaded against reaction of the piston to atmospheric changes, so the base-line remains constant in atmospheric ranges. Pressures are recorded only in the bore-hole, when under pressures exceeding the initial tension.

A new separator section prevents well fluids from entering to working parts; thereby lengthening its useful life, and improving accuracy.

All the above improvements are now available in a new case with "O" ring joint seals which assures even more safety from entry of well fluids. This new joint is more rugged and has withstood pressure up to 13,500 P.S.I. without leakage.

The ELI bottom-hole pressure gauge is manufactured with extreme care, and engineered to withstand the usual abuse liable to be encountered in the field. The great number of gauges in use testifies to the fact that the instrument renders superior service.

The working principle is simple: Well pressures enter ports at the top of the gauge, react against a piston which is held back by a helical spring. On the end of the piston rod is fastened the stylus which records the vertical movement of the piston on a revolving drum chart. The drum chart is driven by a clock mechanism. The ELI Bottom Hole Pressure Gauge is 1¼ inches in diameter, and 66 inches long, weighing 17 pounds. It is run in the well through a suitable stuffing box and lubricator on either .066 or .072 inch standard wire line.

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Humble-Type Subsurface Thermometer
Accuracy to ½ of 1°; pressures to 10,000 lbs.; ranges 60° to 240° F (special order only), 1¼ in. x 62 in.

Calibrating Bath
For calibrating B.H.P. gauges and ELI recording thermometers at operating temperatures.

Dead Weight Tester
For calibrating B.H.P. gauge in 5000 and 10,000 lb. ranges. Accuracy to 1/10 of 1% of pressure under test.

Field Transfer Bottles
660cc and 1000cc, stainless steel, pressures up to 10,000 lbs.

Field Transfer Pump

Bottom-Hole Samplers
Humble-Types A and B, Perco type, and Wofford type.

ELI Mercury Pump
Positive displacement, pressures up to 10,000 lbs.

Heise-Bourdon Tube Gauges
All sizes and ranges, dial sizes up to 16 inches.

Pressure-Volume Cell
Stainless steel, approx. 635cc, pressures up to 10,000 lbs., mounted on trunions, base 9 in. x 12 in., height 14 in., weight 40 lbs.

Pressure Viscosimeter
Humble design, non-corrosive materials, accurate measure of samples for viscosity under reservoir conditions.

Gas-Oil Ratio Equipment
Determines gas liberated from oil under various conditions—flash and differential ratios may be determined.

Water-Bath Assembly
18 in. x 16 in. x 17 in. insulated tank equipped with 3000-W Chromolox heater.

Water Determination Apparatus
100-W Chromolox heater element, stainless steel or brass tubes as specified, 10 extraction cups.

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Permeance of core is read directly, and permeability determined by a single multiplication with length-area ratio. Self-contained and portable, simple to operate.

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● **A. N. Morton** and **A. C. Fetzer** have been elected vice presidents of Mack Trucks, Inc. Both Morton, who is in charge of the company's manufacturing operations, and Fetzer, general sales manager, will continue to make their headquarters in the company's home offices, Empire State Building, New York City.

● **Fred W. Dallas, Jr.**, has been added to the Houston city sales force of Brown Oil Tools, Inc. Dallas studied mechanical engineering at Georgia Tech before joining the Army Air Corps in 1939, where he served until 1945, being relieved from active duty with the rank of major. For two and a half years prior to joining Brown Oil Tools, Inc., Dallas was director of training for Shell Pipe Line Corporation. In addition to his sales activities in Houston for Brown Oil Tools, Inc., he will make occasional trips for the company into the South Texas and Louisiana areas.

Fred W. Dallas, Jr.

● **David Johnson**, new district production engineer for Humble Oil and Refining Company at Refugio, Texas, recently presented an illustrated talk on diamond coring in West Texas before the Petroleum Engineer's Club of Dallas, Texas. He emphasized the valuable nature of new core analysis procedure for determining the porosity of vug and fracture systems in the Ellenburger limestone.

● **W. S. (Buck) Morris**, vice president and general manager of the East Texas Salt Water Disposal Company, and **L. H. Dial**, chief engineer, were the guest speakers at a recent meeting of the Southwest Texas Section of the AIME at Corpus Christi, Texas. They discussed the results of salt water injection into the Woodbine reservoir of the East Texas field.

● **A. F. Rolf**, an assistant secretary of the Allis-Chalmers Manufacturing Company for more than 25 years and associated with the firm's New York district office for nearly 45 years, has retired.

● **Knight C. Templeton**, associated with Roland E. Smith, export representative for Abegg and Reinhold Company, Atlas Production Inc., B & W, Inc., Fullerton Manufacturing Company, Globe Oil Tools Company, and Medearis Oil Well Supply Company, recently departed for an extended visit to the oil fields of Peru, Ecuador, Colombia, Venezuela, Trinidad, and Mexico. Templeton plans to return to the United States the latter part of May.

K. C. Templeton

● **Dr. P. E. Cheney,** director of the production research department of Sun Oil Company at Beaumont, Texas, was the guest speaker at a recent meeting of the East Texas Section of the AIME at Kilgore, Texas. His subject was "Use of Kem-Break" in treating drilling fluids".

● **Charles L. Harding** has been elected a member of the board of directors of the Socony-Vacuum Oil Company, Inc. Harding, formerly a member of the law department, has been coordinating Middle East interests of the company for the last seven months and will continue to function in this capacity.

● **Carl E. Miller** has been named to the research advisory staff of the Battelle Institute, Columbus, Ohio, as part of its expanded fuels and combustion research. Miller, who was key man in the Army's wartime fuel conservation program, will act as a technical advisor on research in coal, gas, and petroleum technology.

● **John Gates,** former assistant day shift shop foreman at Well Equipment Manufacturing Corporation, Houston, Texas, has completed the Weco sales training program and has been named a sales representative in the Houston area, G. R. Winder, vice president and sales manager, announces. Gates has been with the Weco organization more than two years. He formerly was employed by Houston Slush Pump Company and Mission Manufacturing Company.

John Gates

Gates' sales territory will include Houston and the southern Gulf Coast area.

● **John E. Conley,** formerly superintendent of production of the Illinois division for Magnolia Petroleum Company, has moved to Wichita, Kansas, to assume similar duties for both the Kansas and Illinois producing divisions, which have been combined. In the Kansas division, he assumes the position held for many years by **Fred E. Mallonee,** who has retired. Headquarters for the combined divisions will be continued at the First National Bank Building in Wichita.

Wade G. Moriarity has been promoted to production superintendent of the Salem, Illinois, district for Magnolia Petroleum Company. He succeeds **Louis Enloe,** who has been retired.

Walter M. Pittman has been named superintendent of production for the Rodessa, Louisiana, district for Magnolia Petroleum Company. He succeeds **J. M. Courtney,** who has been retired.

Ed L. Downing has been named general superintendent of production for Magnolia Petroleum Company at Dallas, Texas. He succeeds **M. V. C. Bradley,** who was promoted recently to assistant manager of production.

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Lines cannot foul between side plates and sheave

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Staff expanded

R. K. Palmer, field engineer, is now serving users of Totco recorders for controlled vertical drilling in North Texas and South Oklahoma fields, with headquarters at Duncan. Hugh Weathersby has been serving for more than a year in the same field engineering job in West Texas, and makes his headquarters at Odessa.

Expansion of the field engineering staff of Technical Oil Tool Corporation, Ltd., to keep pace with the steadily increasing number of Totco recorders in use in active drilling areas has been a major objective of the company since normal production of Totco equipment was resumed after the war's end. The territory assigned each field engineer is of such size that he can maintain close contact with every drilling operation.

Hugh Weathersby,

R. K. Palmer,

Export agents

Bethlehem Supply Company is pleased to announce the appointment of the Petroleum Machinery Corporation, 30 Rockefeller Plaza, New York 20, New York, as exclusive export agents for Bethlehem Supply Company rotary machinery, hoists, and pumping units.

C.N.G.A. sets dates

At a recent meeting of the executive committee of the California Natural Gasoline Association, dates for that organization's annual June Frolic and its 23rd annual Fall Meeting were established according to the announcement of F. J. Colton, CNGA president. June 5 has been selected as the day and the Rio Hondo Golf Club, Downey, California, has again been chosen as the locale for the fun fest that features an all-day sports program, dinner, and evening show.

CNGA's annual Fall Meeting will be held Friday, October 8, at the Ambassador Hotel, Los Angeles.

New York office

Announcement of the opening of a New York office to handle Atlantic district sales of Peerless pumps is made by F. E. Fairman, Jr., vice president of the Food Machinery Corporation and general manager of its Peerless Division. Sales in this district were previously handled at Ardmore, Pennsylvania. The New York office is at 37 Wall Street, New York 5.

According to B. A. Tucker, Peerless Pump Division sales manager, R. C. Engemoen has been appointed district manager in New York. Engemoen, who until his appointment as district manager was in charge of Peerless vertical pump sales section, will supervise the sales of both the Peerless horizontal and vertical lines and other pumps of the company's manufacture.

Firms merge

The consolidation of The Whitney Chain and Manufacturing Company, and The Hanson-Whitney Machine Company, into Whitney-Hanson Industries, was announced by Winthrop H. Whitney, chairman of the board of the new company. The action brings together two of Hartford's leading industries, each of which will operate as a separate division of the new corporation.

In addition to serving as chairman of the new board, Whitney will be general manager of the Whitney Chain division, while Einar A. Hanson, who has been president of Hanson-Whitney Chain division, will be president of the new corporation. The general manager of the Hanson-Whitney division will be Leon B. Reed, who also will be executive vice president of Whitney-Hanson Industries. Other officers of the new corporation will be Park C. Boyd, secretary, Gordon F. Gilmore, treasurer, and Harry C. Darling, assistant treasurer.

Besides Whitney, Hanson, and Reed, the new board of directors will include Roger Gay, president of Bristol Brass Corporation; Robert E. Carroll, vice president of Arrow, Hart & Hegeman Electric Company; Wilbur G. Stauble, executive vice president and secretary of the Holo-Krome Screw Corporation; Milton H. Glover, vice president of the Hartford National Bank and Trust Company, and Thomas Hewes, senior member of the law firm of Hewes and Awalt, counsel for the new corporation.

Heads division

C. C. Brown, president of Brown Oil Tools, Inc., Houston, Texas, has announced the appointment of Ernest L. Potts as manager of their pipe testing division. Potts has had many years sales and engineering experience in the oil industry. He was with Halliburton Oil Well Cementing Company for seven years, five years as works manager of its Duncan plant and two years as assistant supervisor of mechanical research. During his career in the industry, Potts was also chief engineer for Sharp Deflecting Tool Company, and former Gulf Coast manager for Eastman Oil Well Surveying Company.

E. L. Potts

As manager of the pipe testing division, Potts is in charge of pipe testing operations for Brown Oil Tools, Inc. At present two portable hydrostatic testing units are in service for testing pipe, accumulating tanks, and other types of pressure vessels on location.

Joins Dyke agency

Ed H. Short, Jr., one of the most widely read writers on drilling and production operations, has resigned from the *Oil and Gas Journal* to become associated with the Frank Dyke Advertising Agency, Houston, Texas. Short has a rich background of experience in the oil business which began on both rotary and cable tools in a number of Oklahoma and Texas oil fields. Before taking over the *Journal's* Houston editorial office in 1943, he was connected with the Gulf Oil Corporation, Tulsa, for a period of 17 years. He was chief district engineer for this company during the famous Seminole boom, and following this assignment was in Gulf's Tulsa headquarters as a production engineer on special problems of operation. Following his engineering work he was an executive assistant for a number of years.

Ed H. Short, Jr.

Short has written a great many interesting articles during the last five years in a characteristically vivid, yet terse style that reflects his intimate knowledge of oil field engineering operations in the Greater Gulf Coast area.

Russ Williams dies

Russell B. Williams, 54, account executive for Reincke, Meyer and Finn, Inc., advertising agency, Chicago, died recently at Columbus Memorial Hospital in that city. At one time he was an editorial writer for the *New York Journal of Commerce*.

He leaves his widow, Mrs. Elizabeth Byers Williams, and a brother, Robin S. Williams, sales promotion manager for the International Harvester Company.

Manager of sales

Appointment of Nicholas E. Meyer as manager of sales for Oil Well Supply Company's Wilson-Snyder Division has been announced by Lloyd E. Tracy, vice president—sales, for this U. S. Steel subsidiary.

Meyer, whose headquarters will be at Braddock, Pennsylvania, replaces Howard W. Booth, transferred to "Oilwell's" export division.

Meyer attended Carnegie Institute of Technology five years. He has served continuously with Wilson-Snyder Division since joining Oil Well Supply Company in 1928, making his headquarters at Braddock and New York City.

New branch opened

The Twin Disc Clutch Company, Racine, Wisconsin, manufacturers of clutches and hydraulic drives, opened a new branch sales engineering office in Los Angeles February 1. The Los Angeles office is at 2950 Leonis Boulevard, and serves a territory including California, Arizona, and Nevada. Opening the Los Angeles office brings the number of such branch engineering offices maintained by the Twin Disc Clutch Company to eight.

All Twin Disc activities on the West Coast are under the general supervision of A. E. (Duke) Young, district manager. Sales functions of the California territory are under the direct supervision of Pierce Tyrrell, assistant West Coast district manager. Tyrrell previously was associated with the Twin Disc Hydraulic Division, Rockford, Illinois, in a sales and engineering capacity.

Preston Olney, formerly field service engineer at the Dallas, Texas, branch engineering office of Twin Disc, is manager of the new Los Angeles office.

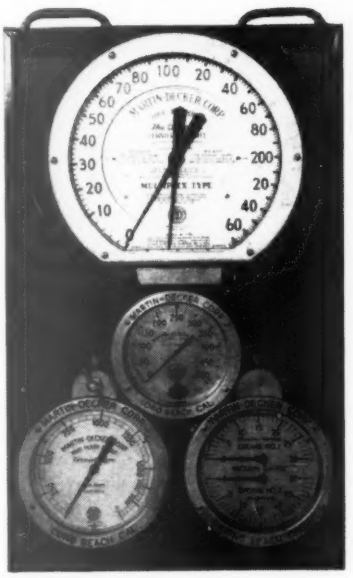
The new Los Angeles Office is equipped with the best machinery available to provide factory repair service. It has an ample stock of replacement parts, competent service mechanics and a modern display room for new products. Floor space totals approximately 7750 square feet.

Five of the eight Twin Disc Branch Sales Engineering offices—Tulsa, Dallas, New Orleans, Seattle and Los Angeles—are equipped to perform repair service, provide engineering assistance and offer stocks of parts. The other three—Detroit, Newark, and Cleveland—offer enginering assistance only. In addition to the branch offices, the Twin Disc Clutch Company has 54 repair parts stations and dealers located at strategic points within the United States and in Canada and Hawaii.

Combines all the advantages of "Sealtite" Construction

RUGGEDNESS—ACCURACY—SENSITIVITY

THE *"Sealtite Clipper"*



THE "SEALTITE" CLIPPER Weight Indicator and Drilling Control Instrument provides the driller with information on all of the important drilling factors—not just weight alone.

An instrument which reliably shows weight, mud pressure, torque and rotary table speed, assembled in a small compact case for jackknife derricks, folding masts and derricks with limited floor space.

It has all the flexibility of a Toolpusher Model but the gauge is not subjected to the violent whip and vibration of the dead line.

You can install or move a "Sealtite" Clipper just as quickly and easily as a Toolpusher type and it will last much longer.

Made in a wide variety of combinations . . . there is a "Sealtite" Clipper available for every purpose.

IT'S TOUGH The "Sealtite" Clipper is built for rough and ready work and can take it.

IT'S SENSITIVE Controlled hydraulic operation with a 6 to 1 ratio super sensitive vernier indicates the slightest change in weight on bit or pull on derrick.

IT'S COMPACT AND COMPLETE Weight Indicator and Vernier Indicator, Mud Pressure Indicator, Steam Torque Indicator and Rotary Table Tachometer are mounted and protected in a compact, strong 16" x 16" x 26" steel box. All indicating gauges are available with recorder except the Rotary Table Tachometer.

IT'S MODERN Immediately adaptable to any type of rig, large or small. The latest thing for use with mast, jackknife, folding derricks or any rig with limited floor space.

IT'S MOVABLE Just remove weight diaphragm from dead line, unscrew Mud Diaphragm, coil up both hi-pressure hoses, place diaphragms and hose in box, shut doors and load in car—that's all there is to it.

IT'S SEALED Vacuum loaded at the factory and permanently sealed. No adjusting—no pumping up. The gauge can be set wherever desired for greatest convenience.

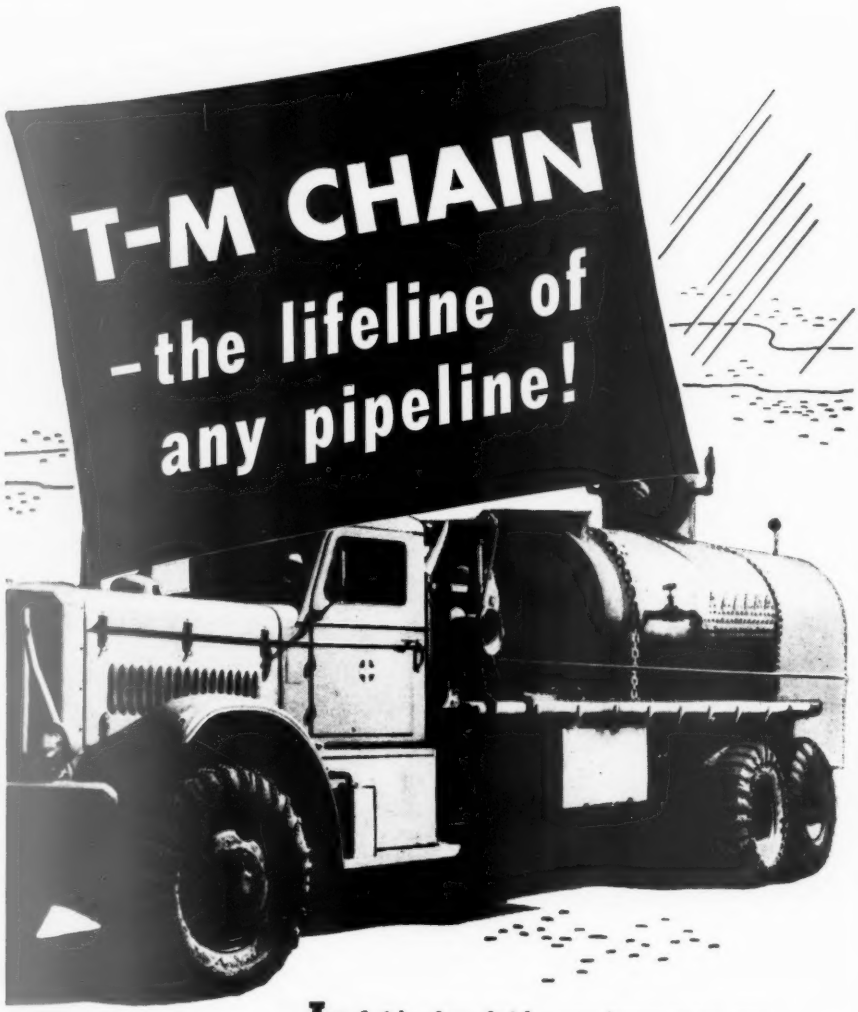
The "Sealtite" Clipper is immediately adaptable to any type of rig, large or small

HOME OF THE WEIGHT INDICATOR

MARTIN DECKER CORP.

LONG BEACH, CALIFORNIA

SAN JOAQUIN VALLEY T. I. CULLEN, BAKERSFIELD, CALIFORNIA
MID CONTINENT DISTRIBUTOR REED ROLLER BIT COMPANY HOUSTON, TEXAS



IN field after field petroleum men are switching to TM Chain for its safety... for its trouble free dependability... for its long life and economy. Yes, they have learned that TM Chain is the life line of any pipe line. They have learned that TM Tire Chains help carry supplies in spite of mud, snow or ice—they have learned that TM Hi Test Chain helps to keep rigs going under the most grueling conditions.

The reasons are as simple as one, two, three—Taylor has been making chain for seventy-five years; the men who fabricate TM Chain have been at it most of their lives; the materials they use are made to Taylor's tried and proved formula.

There's a TM Chain jobber near you. Contact him or write direct. S. G. TAYLOR CHAIN COMPANY, Department O-3, Box 509, Hammond, Indiana.

TAYLOR MADE Chain

"THE BEST BY TEST SINCE 1873."

Heads district

Formerly manager of Kobe, Inc.'s Kansas district, J. T. Lewis has been made manager of the Oklahoma district, succeeding Mr. Prichard. He has been a member of the Kobe organization since May, 1942, starting in the shop in Oklahoma City. He was later transferred to the technical service department as a junior engineer, and, in July, 1943, to sales.

J. T. Lewis

He was promoted to Kansas district manager in December, 1946. Lewis, who is a native of Oklahoma, holds a B.S. degree in mechanical engineering from Oklahoma University, and also attended Oklahoma A. and M., and Oklahoma City University. His oil field experience dates back to 1934.

D + B chief engineer

Dan Duncan, executive engineer of Emsco Derrick and Equipment Company, announces the appointment of David A. Carnahan to the post of chief engineer of the D + B Division of the company. Dave has had wide and varied experience in the oil industry, dating back to his birth on the Shell Lease at McKittrick, California. He attended Stanford University where he graduated with an engineering degree. After graduation, he worked in practically every field in California. Prior to the war he was affiliated with D + B in the engineering department. During the war, Dave was a lieutenant in the Navy, specializing in ordnance research and development. He spent ten months overseas and upon his return was in Washington for seven months teaching bomb disposal. He was then sent to Inyokern, California Naval Ordnance Test Station, Rocket Development Station.

D. A. Carnahan

In his new capacity as chief engineer for D + B he will supervise the development and engineering of subsurface equipment at both the Dallas and Los Angeles plants of the company.

Appoints Arch Rater

Oil Base, Inc., Compton, California, makers of Black Magic oil base drilling fluid, announces the appointment of Arch Rater, Jr., as service engineer. Rater will be stationed temporarily in California but later plans to work out of the Oklahoma City office as permanent representative for Oil Base, Inc., in the Mid-Continent.

Rater was formerly with Halliburton Oil Well Cementing Company and Baroid Sales Division. He served with the Air Corps during the war.

Calgary representative

Alvin B. Geddes, sales representative in the Calgary, Alberta, area, has been appointed district manager in Canada for The National Supply Company, Ltd., with district headquarters at Calgary. A native of Canada, Geddes was educated in the Calgary public schools and was graduated in electrical engineering in 1927 from the Iowa State College. He was associated with Canadian Westinghouse Limited in the Hamilton, Ontario, plant and at Edmonton, Alberta, and later was transferred to Calgary where he followed sales and engineering work.

A. B. Geddes

Geddes joined National Supply in 1943 and was Calgary store manager until last August 2 when he became area sales representative.

Worthington vice president

The board of directors of Worthington Pump and Machinery Corporation has elected Frank J. Whelan a vice president, with headquarters at Harrison, New Jersey. Whelan will be in charge of the industrial and oil field merchandising activities of the corporation. He will be responsible for the sale of Worthington products through industrial and automotive dealers, the sale of power-transmission equipment, and sales to other manufacturers of equipment incorporating Worthington products.

F. J. Whelan

Whelan has been with the Worthington Corporation for the last 14 years in various capacities, and after a year's leave of absence with the War Production Board in Washington, he has been, since 1943, assistant to the vice president, as well as manager of the corporation's reciprocating pump division.

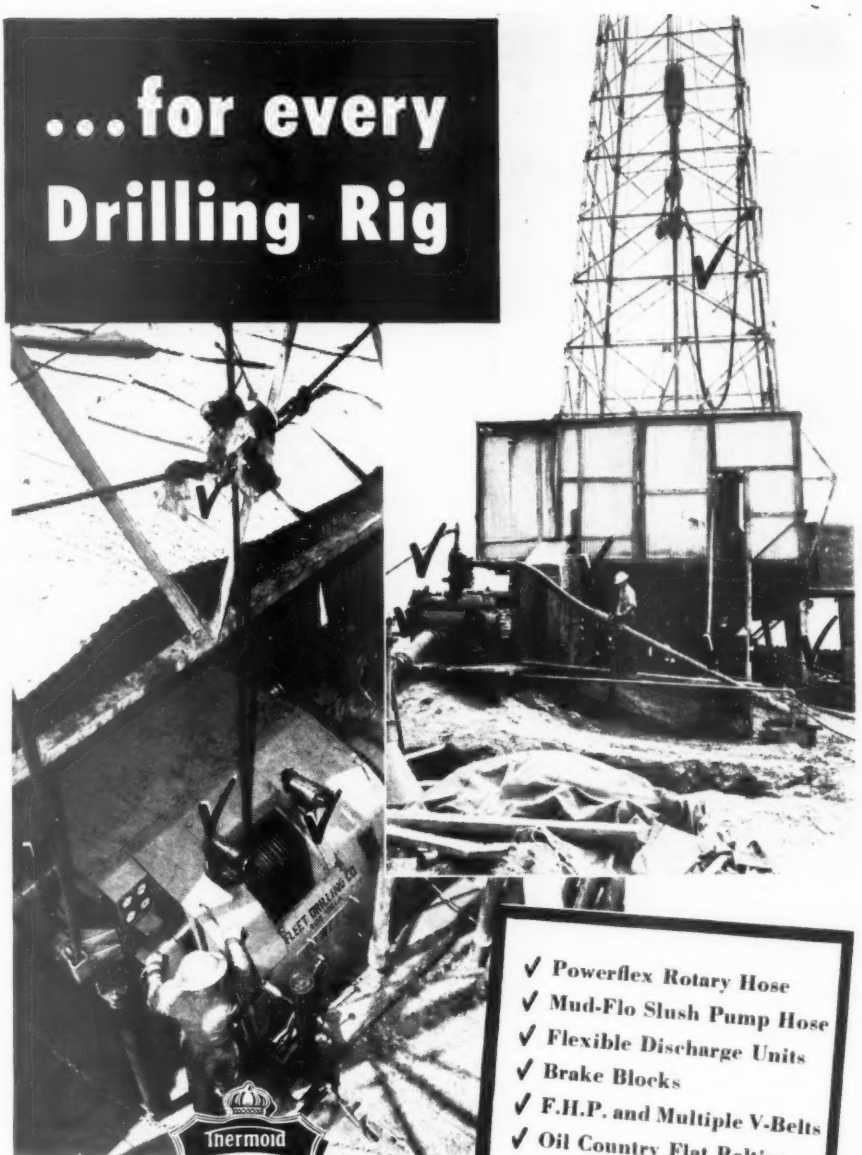
Whelan will be succeeded as manager of the reciprocating pump division by Alvin F. Welsh, now engineer in that division.

Wins safety trophy

The Berwick plant of the American Car and Foundry Company has won the ACF Safety Trophy for 1947, according to an announcement by C. J. Hardy, Jr., president. The award makes the Berwick establishment a fifth-time winner in Group I, which includes the largest of ACF's ten branches.

At presentation held recently, Hardy pointed out that with an average of 3,546 employes throughout the year, the accident rate for all of 1947 was only 9.67 accidents per million man-hours worked.

...for every Drilling Rig



- ✓ Powerflex Rotary Hose
- ✓ Mud-Flo Slush Pump Hose
- ✓ Flexible Discharge Units
- ✓ Brake Blocks
- ✓ F.H.P. and Multiple V-Belts
- ✓ Oil Country Flat Belting
- ✓ Wire Line Turn Backs
- ✓ No-Whip Line Savers
- ✓ Stuffing Box Rings
- ✓ All types of Hose
- ✓ Molded Specialties

Thermoid OIL FIELD PRODUCTS BUILT FOR THE JOB QUALITY VALUE SERVICE

Thermoid products are carefully built with the specific needs of oil field work in mind.

Careful selection of raw materials, latest technical advances plus skilled craftsmanship assure the user of maximum service at lowest cost.

Thermoid Products

Automotive • Industrial
Oil Field • Textile

Thermoid Company, Trenton, N. J., U. S. A.

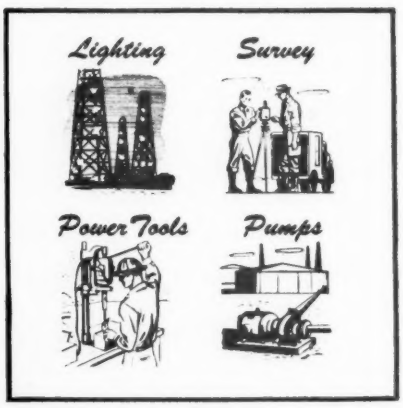
Warehouses in Houston, Los Angeles, Wabash

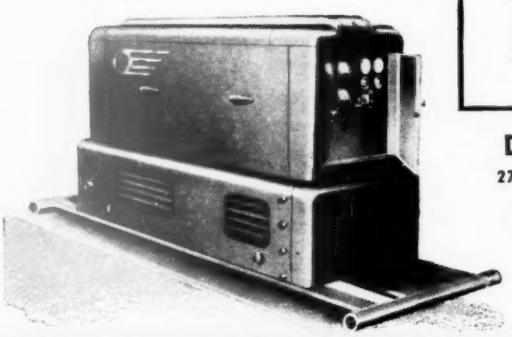
You will find it to be both wise and convenient to specify Thermoid "Built for the Job" products

ONAN Diesel
ELECTRIC PLANTS FOR THE OIL FIELDS

Now there's an Onan Diesel Electric Plant to meet the requirements of any oil field application—to give long, full-capacity service under the severest operating conditions. Available in one-cylinder air-cooled, four and six-cylinder water-cooled models. For continuous heavy-duty operation, stationary or portable.

ONAN DIESEL ELECTRIC PLANTS—2,500 to 35,000 watts. ONAN GASOLINE-DRIVEN ELECTRIC PLANTS—350 to 35,000 watts. ONAN AIR-COOLED ENGINES—5½ and 10 hp (2-cyl.), 3¼ hp (1-cyl.).





D. W. ONAN & SONS INC.
2761 Royalston Ave., Minneapolis 5, Minn.

Write for Special Folder

Onan PRODUCTS

ONAN ELECTRIC PLANTS

WISCONSIN *Air-Cooled* ENGINE
Supplies Power for SHOT-HOLE RIG

Used by a large exploration company for geo-physical work, this truck-mounted shot-hole machine is powered by a Wisconsin Model VP-4, V-type, 4-cylinder air-cooled engine (power range: 26.8 to 31 hp.). These machines are frequently used in isolated districts, necessitating every provision against the possibility of power failure. Wisconsin Air-Cooled Engines are specified for this work because of their proven heavy-duty dependability and complete freedom from cooling chores and troubles.

WISCONSIN MOTOR Corporation
MILWAUKEE 14, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
510 Atlas Building, Tulsa, Oklahoma
M & M Building, Houston, Texas
Oil field distributors for Wisconsin Engines and all types of utility units.

To represent Cameron

According to a recent announcement by E. L. Lorehn, vice president and general manager of Cameron Iron Works, Houston, Texas, D. M. Terry has joined the Cameron sales department.

D. M. Terry

Terry is widely known in the Gulf Coast and Mid-Continent areas where he has been identified with the oil business for the last 17 years as a roughneck, driller, and later as service and sales representative for Halliburton Oil Well Cementing Company and Baker Oil Tools. Terry is now stationed at Oklahoma City and can be reached at the Annex Courts.

Schmidt promoted

Appointment of Charles N. Schmidt as assistant director of advertising, United States Steel Corporation of Delaware, was announced by David F. Austin, vice president-sales. Schmidt comes to the Delaware corporation from American Steel and Wire Company, United States Steel subsidiary, Cleveland, where he has been manager of the advertising division.

C. N. Schmidt

Personnel changes

Three recent changes in personnel have been announced by L. J. Pundt, general sales manager of The S. M. Jones Company, manufacturers of Jones sucker rods. Holt McWorkman, formerly of Tulsa and more recently of Midland, Texas, has been appointed assistant general sales manager with headquarters in the general sales office in Tulsa, Oklahoma. McWorkman has been associated with The S. M. Jones Company for 18 years.

Pundt also announces that C. W. Turner, formerly district representative at Wichita Falls, Texas, has been transferred to Midland as district representative. George M. Blaine, formerly sales representative in Tulsa, has been appointed district representative with headquarters at Wichita Falls, Texas.

Wheatley promotions

Several promotions were made among personnel of the Wheatley Pump and Valve Manufacturers at a board of directors meeting held recently. Frank Wheatley, Jr., was promoted to the post of executive vice president. Frank Wheatley, Sr., was re-elected president of the firm, and Gus Baker, Jr., was named vice president and general manager, and William J. Gray, veteran of 30 years with the firm, was elevated to

vice president in charge of manufacturing.

Frank Wheatley, Jr., in making the announcement of action of the board of directors in the annual meeting, said that Miss Dorothy Page, former secretary-treasurer of the firm, is retiring after more than 20 years' service with the company. She will be succeeded by Dan L. Lingo.

Wheatley announced that Earl Wagner, who has spent more than 30 years with the oil field equipment manufacturing company, is retiring from his position as shop superintendent. His position will be filled by Grady Maguire.

Kirberger named

Earl Kirberger, one of Franks Manufacturing Corporation's 15-year men has been named to handle the Oklahoma and Kansas Sales territory for the Tulsa rotary drilling rig and servicing unit manufacturer. Kirberger is well qualified to handle the position, according to Carl White, Jr., president. Having started with Franks in its early stages, he has been on the road before, both in the sales and service departments, and during the war worked in the production department.

Earl Kirberger

Chief engineer

Frank A. Jones, formerly associated with Terminal Railroad Company, St. Louis; Busch-Sulzer Bros. Diesel Engine Company, St. Louis; and the Missouri Pacific Railroad, has been appointed chief engineer of Dearborn Chemical Company, with headquarters at the company's general offices, 310 South Michigan Avenue, Chicago, Illinois. He will supervise all engineering activities, foam meter equipment, and the development of new equipment.

E. A. Goodnow, whom he succeeds, has relinquished his position due to ill health, but he will remain with the company as assistant chief engineer.

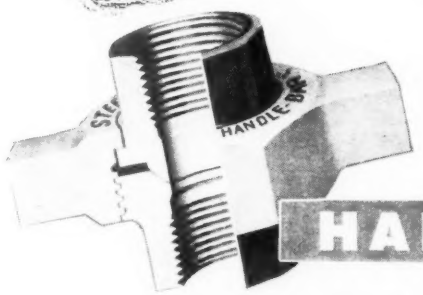
California distributor

A. Leschen and Sons Rope Company, St. Louis, Missouri, has announced that effective April 1, 1948, its entire line of oil field wire ropes will be distributed in California by the new firm of Ball and Black Supply Company, whose address is 2439 Hunter Street, Los Angeles. This firm is composed of two experienced wire rope men, C. R. (Chuck) Ball and C. H. (Cliff) Black. Ball has been identified with the California oil fields for about 20 years. Black has been active in California for 25 years, and prior to that he spent a good many years in the Mid-Continent area.

The A. Leschen and Sons Rope Company has also announced establishment of a warehouse at 2439 Hunter Street, Los Angeles, where a complete stock of oil field ropes is being carried.

there is no Problem

OF DEPENDABILITY WITH THESE PRECISION BUILT, EXTRA HEAVY FORGED STEEL UNIONS



HANDLE-BAR

Sizes 3/8" to 4"

These easy to handle Hi-Speed Handle-Bar Unions have integral steel to steel seats, or completely fused bronze to bronze seats. The nut threads are modified Acme to facilitate easy and speedy assembly and disassembly. The seat design is a 45 degree cone, machined and cold rolled, to a ball seat on the male end. Furnished in black hub ends with Udylited nut, or all rustproof with Udylited hub ends and Parkerized nut.

4000 Test Unions sizes 3/8" to 4" inclusive are furnished with Briggs Standard steam threads in pipe ends.

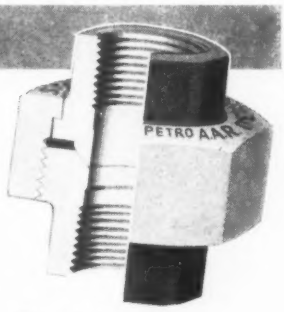
6000 Test Unions sizes 2" to 4" inclusive have long pipe ends with A.P.I. line pipe threads.

HANDLE—BAR Unions are recommended for all services. Use a hammer instead of a wrench to tighten or loosen the nut.

PETRO

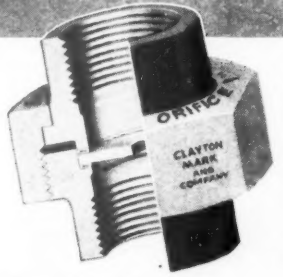
This Union has features that make it the most universally used Union. It is made to A.A.R. standards with integral steel to steel seats. The seat design is a 45 degree cone, machined and cold rolled, to a ball seat on the male end. The ends and nut are extra heavy and the nut threads are permanently lubricated and rustproofed with Udylite Cadmium.

A partial list of PETRO'S proven services include pressures from a vacuum to 3000 lbs.; Temperatures from 100° below zero, F., to 1000° above zero F.; on Steam, Gas, Air, Oil, Gasoline, Ammonia, Chemicals, and all other services in which Steel or Wrought Iron Pipe is used.



Sizes 1/8" to 3"

ORIFICE



Sizes 1/4" to 3"

"ORIFICE" Unions, screwed, or socket weld are widely used for flow control of Steam, Oil, Ammonia, Chemicals, Water, Gas and Air. Also for metering and measuring. The ORIFICE is recommended for working pressures of 600 lbs. at 900° F., or 2000 lbs. at 150° F. Furnished with 18-8 stainless steel orifice plate and steel jacketed asbestos filled gaskets. These are set in a groove of solid steel to facilitate ease of tightening and to safeguard against possible blowing of the gaskets and resultant trouble.

The nut threads are Cadmium plated (UDYLITED) for permanent thread lubrication.

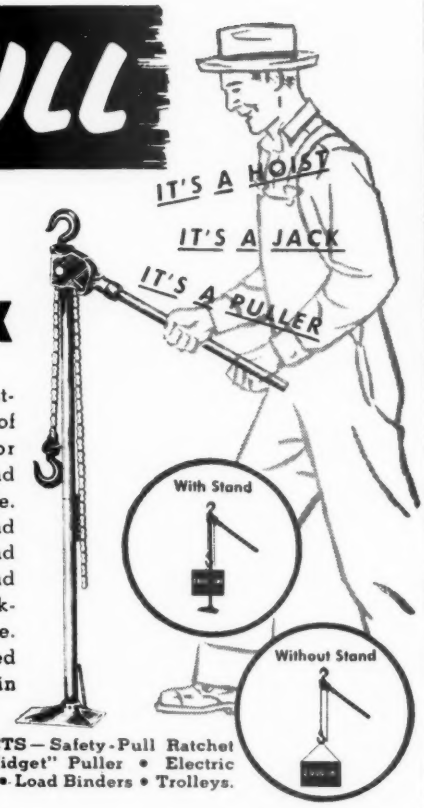
ORDER BY TRADE NAME FROM YOUR LOCAL JOBBER

ORIGINATORS AND PIONEERS OF STEEL UNIONS SINCE 1912

CLAYTON MARK & COMPANY

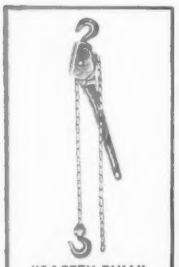
1900 DEMPSTER STREET • EVANSTON, ILLINOIS

LIFT or PULL



Easier and Faster—
with the Amazing New
COFFING HOIST-JACK

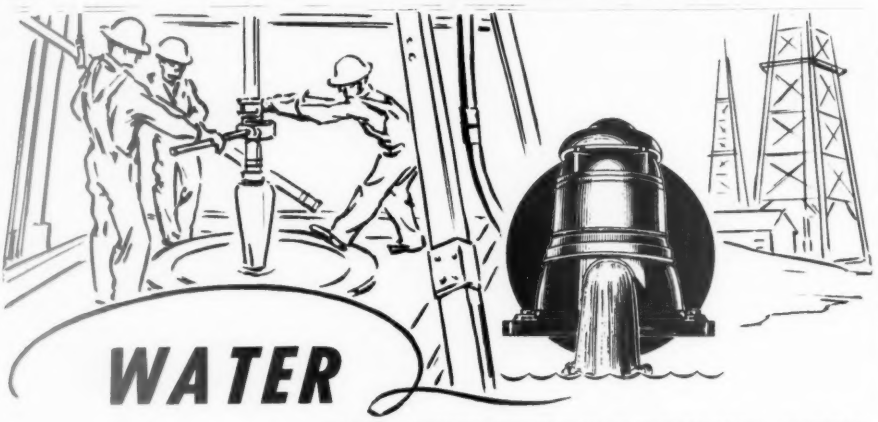
A versatile 3-in-1 tool, this new Coffing Hoist-Jack provides greater efficiency and ease of operation on scores of lifting, pulling or stretching jobs. Simplified ratchet design and sturdy construction assure safety and long life. Weighs only 23 pounds, yet lifts a 2000 pound load. Operates with stand as a jack, or without stand as a hoist or binder; quickly set up, easily portable. Tested to 100% over rated capacity. Write for Bulletin OHJ-1.



"SAFETY-PULL" HOISTS
Ratchet Lever type; Capacities from ¾ to 15 tons

OTHER COFFING PRODUCTS—Safety-Pull Ratchet Lever Hoists • "Mighty-Midget" Puller • Electric Hoists • Spur-Geared Hoists • Load Binders • Trolleys.

COFFING HOIST COMPANY
DANVILLE, ILLINOIS



WATER
FOR EVERY PROCESSING NEED

For field operation, refining or pumping station use Layne well water systems are built and installed to produce great quantities of water at the absolute minimum in cost. Futhermore, Layne well water systems can always be depended on to give years and years of service at little or no upkeep cost. Actual records show that Layne installed well water systems—size for size, produce more water than any other system on today's market. As pioneers in the water producing field, Layne has long maintained uncontested leadership. For illustrated literature, address Layne & Bowler, Inc., General Offices, Memphis 8, Tenn.

LAYNE
WELL WATER SYSTEMS

Wins Lincoln award

H. D. Hilborn, chief structural engineer at the Houston plant of Emsco Derrick and Equipment Company, was recently given a Lincoln award for his paper on the design and construction of the new Emsco 18 I' Bulge Type Portable Mast for drilling to depths in excess of 15,000 ft. In competition with entries received from six continents, Hilborn received the second highest classification award and was presented a cash sum of $2200. The Lincoln Award is made periodically by the James F. Lincoln Foundation for outstanding achievement in connection with scientific research and development. Total awards amounted to $200,000.

H. D. Hilborn

G. S. Monroe succumbs

George Stuart Monroe, for the last 24 years a research chemist with the Universal Oil Products Company, died February 25 at his home in Berwyn, Illinois. He was 55 years of age. Monroe was graduated from the University of Illinois in 1917, with the B.S. degree in chemistry. His first position upon graduation was with the Newport Company, where he remained until 1924, when he joined Universal Oil Products Company.

G. S. Monroe

His first published paper appeared in 1917: in *Industrial and Engineering Chemistry*. Since 1930 he had worked in close collaboration with Professor V. N. Ipatieff, with whom he published numerous papers dealing principally with reactors at high pressures and temperatures, such as synthesis of methanol from carbon dioxide and hydrogen, and solubilities of gases under high pressures.

His most recent contribution to the chemical literature was "High Pressure Laboratory Flow Apparatus." Many patents dealing with the treatment of hydrocarbons have been issued to him.

Appoints sales firm

Oil Base, Inc., Compton, California has appointed Petro-Tech Service Company, Ca, Inc., to represent Black Magic oil base drilling fluid for sales and service in South America. With headquarters in Maracaibo, Venezuela, Petro-Tech has direct representation in Trinidad, Colombia, Peru, Ecuador, and Venezuela. Headed by Russell Keener and Keith Miner, the service company has wide experience in servicing problems demanding oil base muds in the Latin American countries.

Opens Dallas branch

On the fifth anniversary of the founding of the Dow Corning Corporation, company officials announced the opening of a new branch office in Dallas, Texas. Max H. Leavenworth has been named head of the new office. Prior to joining Dow Corning, Leavenworth was a member of the staff of instructors for the Army Aircraft Mechanics School at Willow Run. With the completion of that project he joined Dow Corning and spent a year in the various laboratories and product development groups maintained by Dow Corning. For the last two years he has been acting as a technical representative attached to the corporation's home office in Midland, Michigan.

M. H. Leavenworth

Wins award

The Wilmington plant of the American Car and Foundry Company has won the ACF Safety Trophy for 1947, according to an announcement by C. J. Hardy, Jr., president. The award makes the Delaware establishment a fourth-time winner in Group II, which includes the smaller of ACF's ten branches. ACF Berwick was in the lead in Group I.

At the presentation dinner held at the Hotel DuPont, Hardy pointed out that with an average of 274 employes throughout the year, they were able to work 11 months without a lost-time injury and for all of 1947 with a rate of only 3.74 accidents per million man-hours worked.

Lane-Wells changes

In order to handle more efficiently the record increase in volume of business, Lane-Wells Company has made the following changes and re-assignments in field personnel, according to Morton T. Higgs, manager of field operations.

R. B. Downing has been appointed Mid-Continent division manager following the resignation of R. B. McCullar from that position. "Ike" Downing joined Lane-Wells in 1941 after previous experience as Kansas division geologist of Barnsdall Oil Company, and as a consulting geologist with headquarters in Wichita, Kansas. Downing's experience with Lane-Wells includes service as sales engineer, geologist, superintendent of the Oklahoma City district, and division sales manager.

C. L. Kirkman, formerly assistant district superintendent at Great Bend, Kansas, succeeds Downing as division sales manager in Oklahoma City. R. H. Waggoner, formerly sub-district superintendent in Russell, Kansas, has been transferred to Great Bend to succeed Kirkman, and A. N. Downing, formerly gun perforator operator in Russell, has been made sub-district superintendent.

L. V. Steffey, formerly assistant district superintendent in Oklahoma City, has been transferred to Salem, Illinois, as district superintendent, succeeding R. G. Echols, resigned. E. C. Doane, formerly sub-district superintendent at Seminole, Oklahoma, has been appointed to Steffey's former position, and Sidney R. Pittman, formerly an operator in Healdton, Oklahoma, has succeeded Doane.

Other recent changes include the advancement of J. D. Dunigan from the position of sub-district superintendent at Guymon, Oklahoma, to district superintendent at the same point, and the transfer of Ray Edwards, formerly operator in charge at the Ulysses truck station, to the position of sub-district superintendent of the recently established Garden City, Kansas, sub-district.

In the Gulf Coast Division, E. A. Radack, formerly sub-district superintendent at Laurel, Mississippi, has been moved to Shreveport, Louisiana, as assistant district superintendent.

J. C. Strickland, formerly operator in charge of the Opelousas, Louisiana, truck station, replaced Radack, and J. C. Orr has replaced Strickland. Leon Pyle has been made operator in charge of the new Monroe, Louisiana, truck station. E. F. Stokes has been made operator in charge of the new Lubbock, Texas, truck station.

ATTENTION...

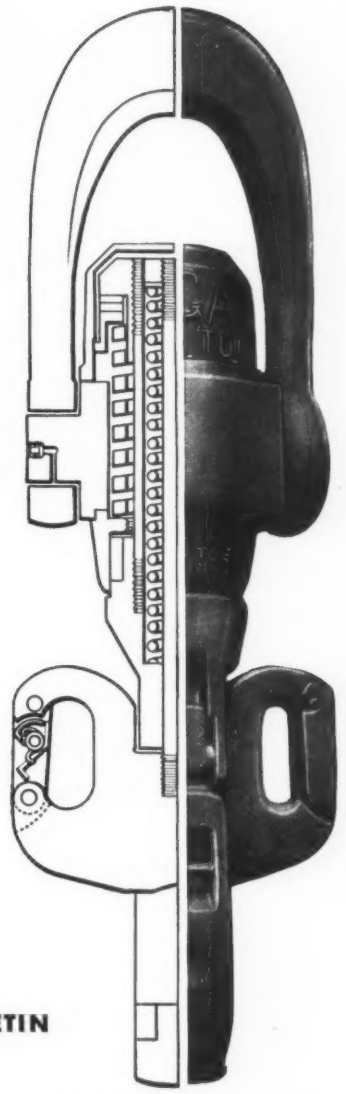
PORTABLE OPERATORS!

IF IT IS COMPACTNESS YOU REQUIRE

Because of unique telescopic action, which has been designed into the Regan 200-ton Casing Hook, Regan is able to offer a saving in overall working length of approximately

three feet

over any other hook of this type offered at the present time.



LOOK AT THESE FIGURES:

Length of Regan Casing Hook	200-ton	300-ton
Overall length	85"	101"
Length Working to Hook Saddle	69"	83"
Length Working to Elevator Yoke	56¾"	60"
Spring travel, Main Hook	2½"	2½"
Spring travel, Elevator Yoke	7½"	9½"

SEND FOR BULLETIN

Regan Forge & Engineering Co.
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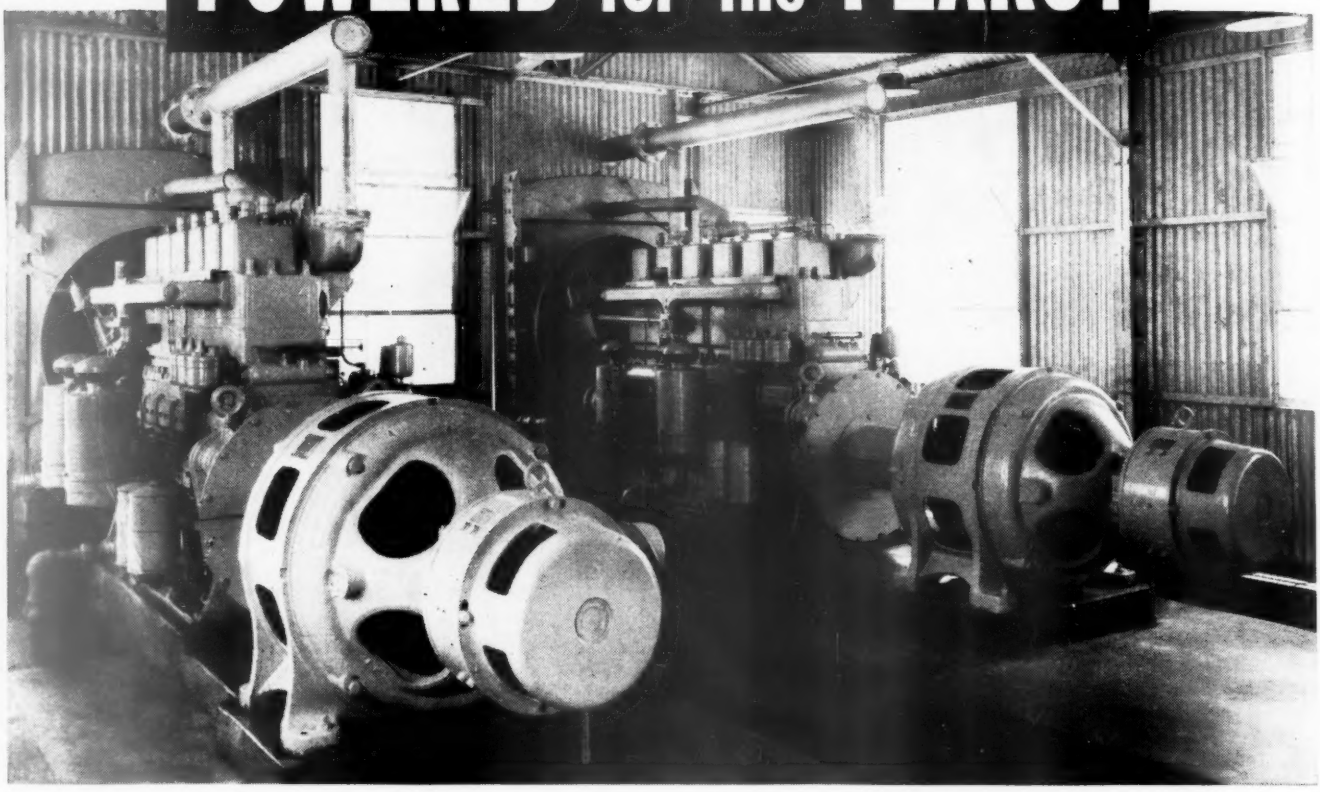

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This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue; 73-79, inclusive, in the January, 1944, issue; 80-82, inclusive, in the April, 1944 issue; 83-85, inclusive, in the July, 1944, issue; 86-88, inclusive, in the October, 1944, issue; 89-91, inclusive, in the January, 1945, issue; 92-94, inclusive, in the April, 1945, issue; 95-97, inclusive, in the July, 1945, issue; 98-100, inclusive, in the October, 1945, issue; 101-103, inclusive, in the January, 1946, issue; 104-106, inclusive, in the April, 1946, issue; 107-109, inclusive, in the July, 1946, issue; 110-112, inclusive, in the October, 1946, issue; 113-115, inclusive, in the January, 1947, issue; 116-118, inclusive, in the April, 1947, isisue; 119-121, inclusive, in the July, 1947, issue; 122-124, inclusive, in the October, 1947, issue; 125-127, inclusive, in the January, 1948, issue.

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HORSEPOWER REQUIREMENTS AND LOAD FACTORS OF ROTARY DRILLING RIGS

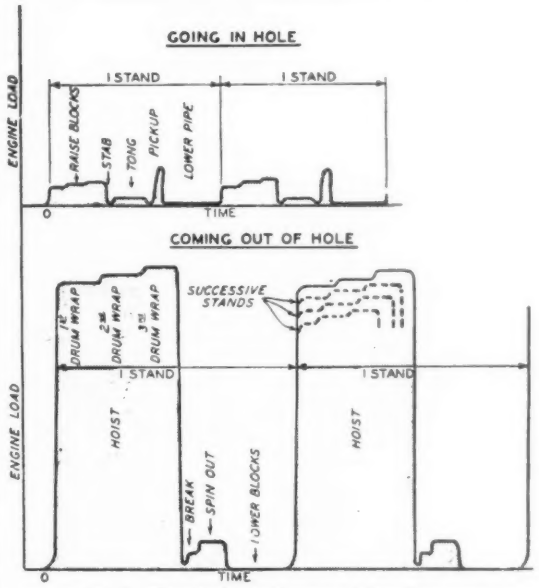

FIG. 1. Typical single-stand load curves.

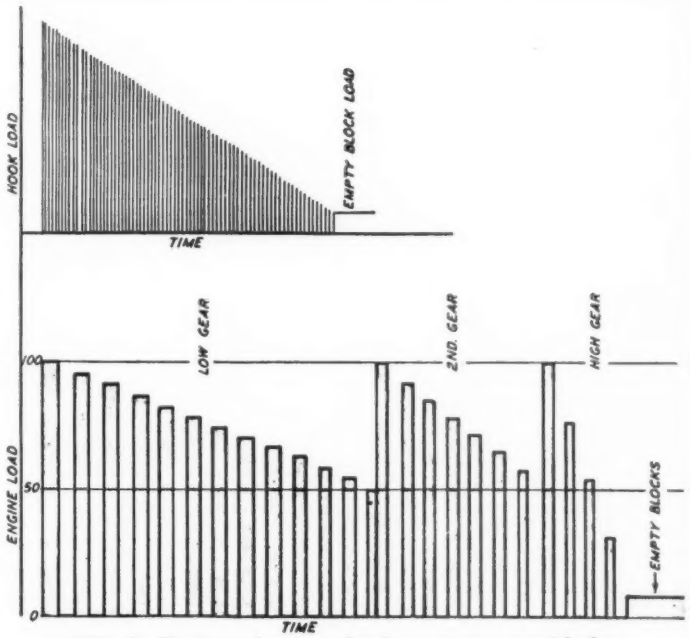

FIG. 2. Hook and engine loads coming out of hole.

Before attempting to purchase or apply motive power to an oil-well drilling rig, an extremely thorough study of the load cycle, motion cycle, and operating habits is vitally necessary. Many failures of equipment to perform satisfactorily have been caused by the question "how much horsepower?" instead of "how is the horsepower used?" When attempting to use a new method of power application on a drilling hoist, this intimate knowledge is particularly essential in making the most of the characteristics of the new transmission in order to yield its best performance at the hook.

A. Hoisting. Fig. 1 shows a typical set of single load curves for "going in the hole" and "coming out of the hole." The "pickup" and "hoisting" peaks on either curve will vary from below full value in each gear, depending on the transmission method employed.

Fig. 2 shows typical hook loads and engine loads on the hoisting cycle with a mechanical transmission.

Table 1 gives some idea of the overall load factors that may be expected on drilling rigs of various classes. The values have been taken partially from actual field results and partially from interpolations. The figures were worked back from actual fuel consumption figures on a number of locations. They are, however, subject to relatively wide variations in each class, depending on whether the wells are "exploration" or "development" wells. In the latter cases, the load factors should decrease and on the former they will normally increase.

B. Drilling. Fig. 3* shows a typical buildup of load while drilling as the well progresses from start to full depth.

On internal-combustion engined rigs, in particular, the peak horsepower output of the engines is obviously the maximum obtainable from the rig. In fact, maximum drilling horsepower should be about 85 per cent of peak intermittent or "hoisting" horsepower unless engine trouble is to be expected. Peak horsepower can be employed for short periods only, when drilling, for this reason.

C. Auxiliaries. On most engine driven rigs, it is the common practice to rob power from the main engines to supply the majority of the normal auxiliary power. When a rig is operating at full load, the use of separately driven auxiliaries will increase the drilling capacity of the rig by making the auxiliary power, normally robbed from the engines, available for drilling use.

The tabulation in Table 2 is illustrative of the order of main power and auxiliary power requirements on an extra heavy rig.

From Table 2 it can be seen that the total auxiliary power is in the neighborhood of 5 per cent. This excludes engine cooling fans, which are part of the engine and would bring the auxiliary power up to about 15 per cent of the total produced by the engines.

TABLE 1. Load factors for oil-well drilling.

Class of rig	Gulf Coast drilling				Hard rock drilling			
	Light	Medium	Heavy	Ex. heavy	Light	Medium	Heavy	Ex. heavy
Rig horsepower*	400	609	1,000	1,500	400	600	1,000	1,500
Drilling depth	5000	8000	10,000	12,000	6000	9000	11,000	15,000
Avg. load factor, per cent	45	43	33	28	35	31	27	23
Avg. hp load	180	258	330	420	140	186	270	345
Daily hp-hr	4320	6200	7920	10,200	3360	4430	6,480	8,300

*Assuming all this horsepower available for primary drilling service. Auxiliary service requirements are extra.

TABLE 2. Power services.

Main	Auxiliary
(i) Drilling	
a. Main slush pump	a. Lights
b. Rotary table	b. Washdown pump
c. Auxiliary slush pump (alternate to (a) when needed)	c. Mud screens
	d. Bug blower fans
d. Mud mixing pump	e. Air supply
	f. Blowout preventers
(ii) Hoisting	
a. Hoist	a. Lights
b. Rotary—breakout	b. Washdown pump
	c. Bug blower fans
	d. Air supply
	e. Blowout preventers
	f. Fill up pump

Approximate auxiliary horsepower required

Service	Hp
Lights, etc.	7½
Washdown pump	7½
Mud screens (2)	4
Bug blowers (2)	4
Air supply	5
Fill up pump, BOP pump	20
	48

Say, 60 hp available.

*See sheet 2, P 422.34.

Taken from the article, "Application of internal-combustion engine power to rotary drilling rigs, by W. S. Crake, Shell Petroleum Company. Presented before The American Society of Mechanical Engineers, Houston, Texas, October 5-8, 1947, and published in *The Petroleum Engineer*, December, 1947, pages 70 to 80, inclusive.

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HORSEPOWER REQUIREMENTS AND LOAD FACTORS OF ROTARY DRILLING RIGS

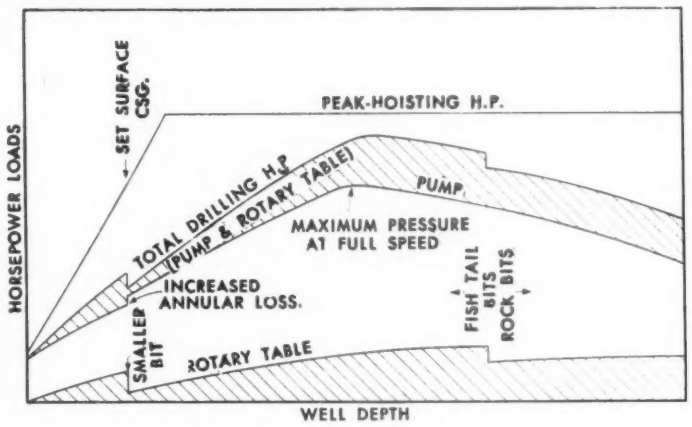

FIG. 3. Typical drilling well horsepower loads (one size of drill pipe).

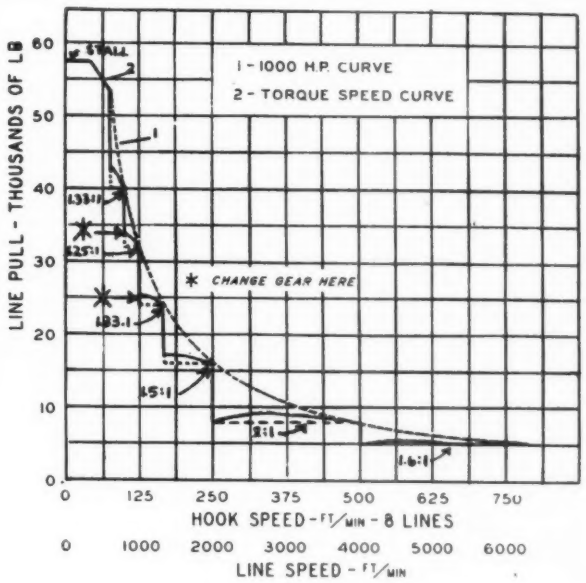
LINE PULL - THOUSANDS OF LB
1 - 1000 H.P. CURVE
2 - TORQUE SPEED CURVE
STALL
* CHANGE GEAR HERE
HOOK SPEED - FT/MIN - 8 LINES
LINE SPEED - FT/MIN

FIG. 4. Mechanical 6 speed curves.

The auxiliaries would run simultaneously sufficiently often that it should be assumed that they would be using power from the main engines for a considerable part of the day's run. There is, thus, little out of the ordinary in auxiliary load characteristics, but they must be considered and the most vital pieces of auxiliary equipment are usually supplied in duplicate.

● **Effect of load characteristics on choice of prime movers.** *A. Flexibility.* As can be seen from the hoisting portion of the load curve in Fig. 1,* the load requires the most rapid possible application of accelerating torque and a horsepower delivery that mounts as rapidly as the load reaches full speed.

As no mechanical coupling methods, such as friction clutches, will stand the wear and tear of being thrown in against engines running at full speeds, some method of reducing these shock loads is vital on all drilling machinery. On direct mechanical drives, the only compromise is to connect the load with the engines running at about idling speed and then accelerate the engines. This does not produce any torque multiplication, but is capable of being withstood by clutches. For this reason, drilling rigs generally require engines with rapid acceleration characteristics and relatively light flywheels—automotive type performance—to obtain the desired acceleration and reduce maintenance costs on transmission members.

The use of slow speed, heavy duty engines has not, to the writer's knowledge, been successful in any field application for these reasons and the list of present day hoists are no exception to this statement. When using diesel engines, with their known flat torque curves, the shocks to transmission are doubly difficult to withstand.

B. Governors and flywheels. As mentioned above, all transmission methods require engines highly responsive of speed to load and light flywheels are, therefore, highly desirable. General practice is to use engine throttle controls with a maximum governed speed of the engine. All drilling loads are of the type that make the increasing of torque of automatic opening of the throttle by governors highly undesirable. If the torque raises at any throttle set point, the speed should drop accordingly. This is particularly the case when rotary tables are driven through speed reduction gears and where governor controlled engines may open up, unbeknown to the operator, and very easily cause drill pipe failures or "twistoffs."

The single exception to the above points is the use of heavy duty constant speed engines for electric drilling in which the load is coupled and accelerated, not through friction clutches but by electric motors. In this case, power input can be easily controlled by the operator. In view of the undesirable nature of running any engines on a drilling rig at full speed continuously and the primary requirement of portability, the writer feels that, even in this application, the light, flexible engine is desirable, along with some device that idles the engine when it is not required for full speed operation.

C. Load coupling. The most modern hoists tend toward complete friction clutch drives, both for speed changes and main load coupling. The actual load coupling unit varies with the various types of transmissions enumerated below. All types can best be operated by starting from near idling speed before coupling and by accelerating the load as the engine itself accelerates to the required power output speed.

TABLE 3. Hook to engine shaft horsepower data.

	Per cent
a. Mechanical efficiencies	
Hook to drum	92
Drum to average engine	75
Overall	69
b. Electrical efficiencies	
Hook to drum	92
Drum to motor	90
Motor and cables	90
Generator	92
Overall	68.5
c. Hydraulic efficiencies	
Hook to drum	92
Drum to average engine	75
Torque converter, average	81.5
Overall	56.25

Horsepower data	Engine shaft hp for 1000 hook hp	Hook hp for 1450 engine shaft hp
Mechanical	1450	1000
Electrical	1460	996
Hydraulic	1775	820

● **Transmissions and their characteristics.** The following paragraphs are an attempt on the part of the author to give a direct comparison between the mechanical, electrical, and hydraulic methods of transmission, when properly applied to drilling hoists and other drilling machinery. The specific examples are chosen as being representative of transmission method and will show the hoist speed ratios and output torque speed characteristics on each of the three methods of drive. A 1000-hp hook load curve is shown, which is used as an example of a rig of about 1500-hp input.

In all the curves, a 1000-hp delivered power is assured, with some slight increase shown as the efficiency of the drive improves. As a matter of interest, and of considerable concern to users, the overall efficiency of the three methods are given in Table 3.

*See sheet 1, P 422.34.

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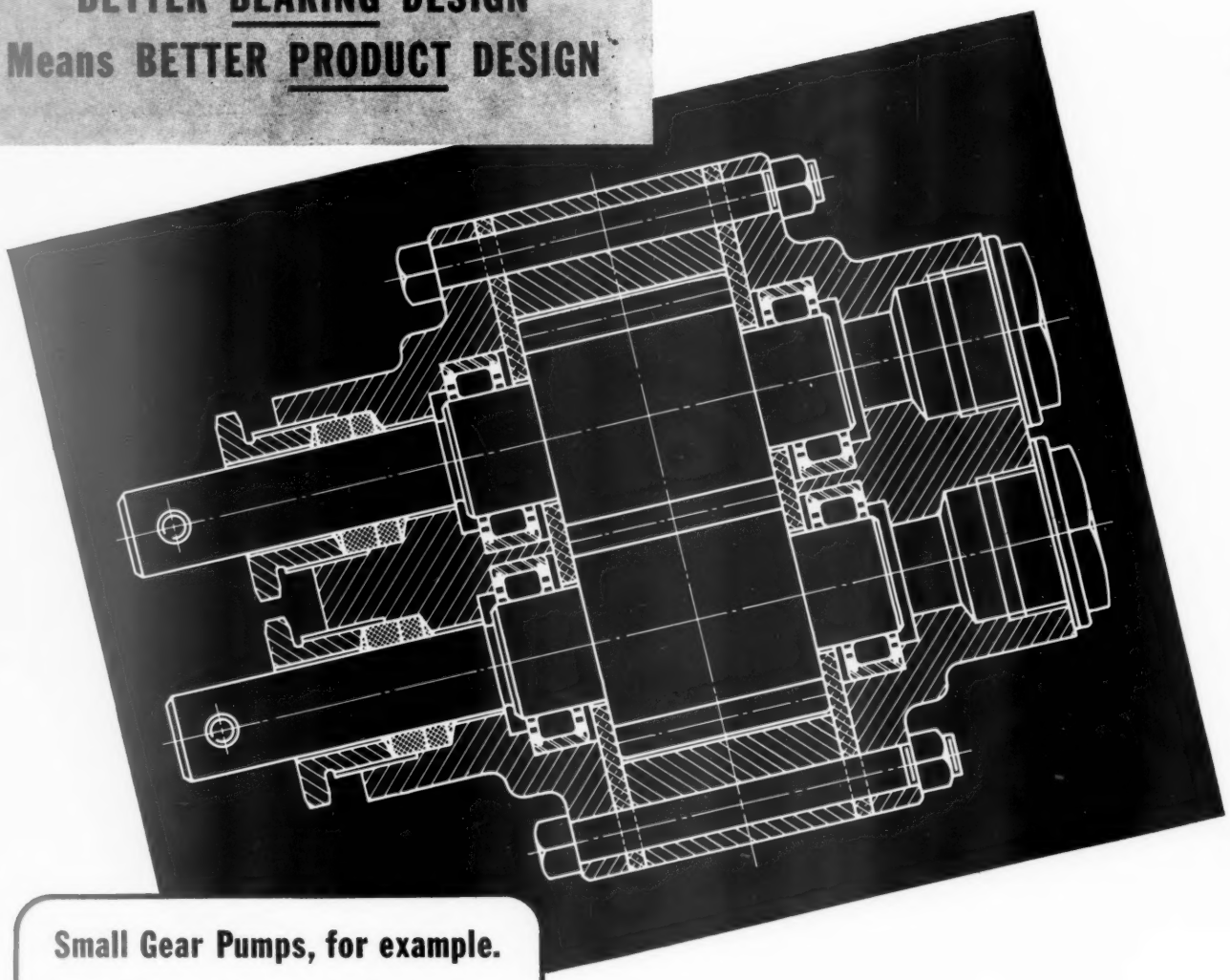

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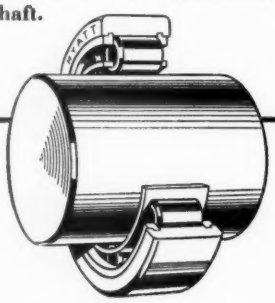

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METHOD OF DETERMINING NUMBER OF PLATES FOR A RECTIFYING COLUMN

Fig. 1 represents an expansion of the familiar McCabe-Thiele diagram. Within square OPQR are represented equilibrium curve ODQ and two operating lines AK and BD. Extension of the equilibrium curve and rectifying line to the right to the point of intersection at I permits the construction of rectangle HIJK, within which are represented the operating conditions of the section of the column above the feed plate. The rectifying line is the diagonal of this rectangle; this suggests that the upper part of the column is apparently operating at total reflux.

Points (x_0, y_0) and (x_E, y_E), the intersections of the operating line and the equilibrium curve, may be located by solving simultaneously the equation of the operating line, $y = mx + c$, and the equilibrium relation, $y(1-x)/x(1-y) = a$, obtaining: $m(a-1)x^2 + (m - a + ac - c)x + c = 0$ and $(a-1)y^2 + (m - a - ac + c)y + ac = 0$. The solution of these quadratics for x_0, x_E, y_0, and y_E is obviously somewhat involved and leads to cumbersome expressions. However, the products x_0x_E and y_0y_E are useful and are simply stated: $y_0y_E = ac/(a-1)$ and $x_0x_E = c/m(a-1)$. Dividing these equations and rearranging gives $y_0y_E/ax_0x_E = m$, and, since $m = (y_E - y_0)/(x_E - x_0)$,

$$(y_E - y_0)/(x_E - x_0) = y_0y_E/ax_0x_E \quad . . . . . (1)$$

Consider the arc cut by a straight line through points (x_0, y_0) and (x_1, y_1). From analogy to Equation 1 this leads to

$$(y_1 - y_0)/(x_1 - x_0) = y_1y_0/ax_1x_0 \quad . . . . . (2)$$

and, for the straight line through points (x_1, y_1) and (x_E, y_E),

$$(y_E - y_1)/(x_E - x_1) = y_1y_E/ax_1x_E \quad . . . . . (3)$$

Dividing Equation 2 by Equation 3 gives

$$\frac{(y_1-y_0)\ (x_E-x_1)}{(x_1-x_0)\ (y_E-y_1)} = \frac{y_0x_E}{x_0y_E} \quad . . (4)$$

which represents ratios of slopes from the top plate to opposite corners of the rectangle.

A ratio around point (x_2, y_2) results in the expression

$$\frac{(y_2-y_0)\ (x_E-x_2)}{(x_2-x_0)\ (y_E-y_2)} = \frac{y_0x_E}{x_0y_E} \quad . . (5)$$

A similar expression may be written for each plate above the feed plate. The product of all these expressions leads to the series

$$\frac{(y_1-y_0)\ (x_E-x_1)}{(x_1-x_0)\ (y_E-y_1)} \cdot \frac{(y_2-y_0)(x_E-x_2)}{(x_2-x_0)(y_E-y_2)} \cdot \frac{(y_3-y_0)}{(x_3-x_0)} \cdots \frac{(y'_q-y_0)\ (x_E-x_q)}{(x_q-x_0)\ (y_E-y'_q)} = \left(\frac{y_0x_E}{x_0y_E}\right)^{n_1} \quad . . . . . (6)$$

Taken from the article, "Calculation of number of theoretical plates for rectifying column," by A. E. Stoppel, published in *The Petroleum Engineer*, Reference Annual, 1947, pages 189 and 190.

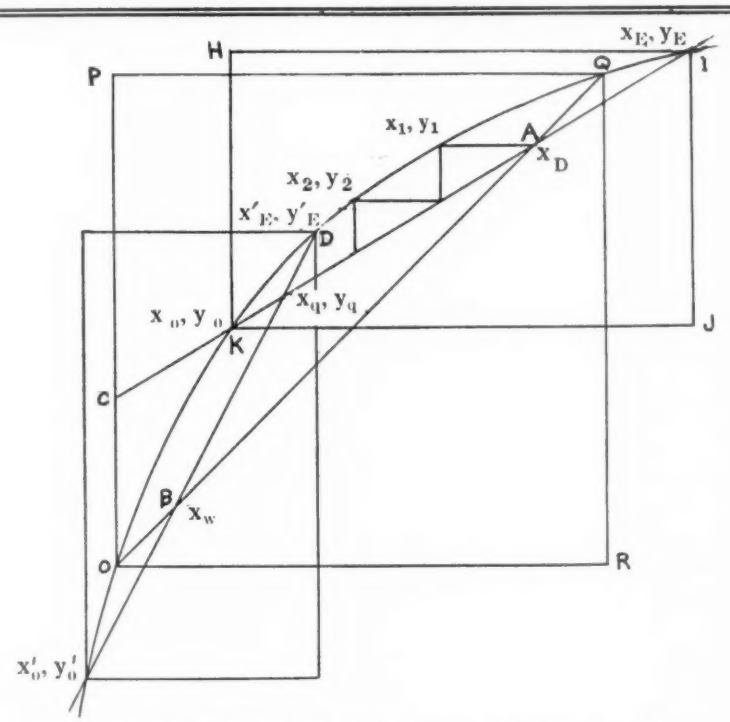

FIG. 1. Modified McCabe-Thiele diagram for distillation column.

In Fig. 1 point (x_1, y_2) falls on the diagonal of the rectangle. It is obvious from the geometrical construction that area $(x_E - x_1)\ (y_2 - y_0)$ = area $(y_E - y_2)\ (x_1 - x_0)$. Also $(x_E - x_2)\ (y_3 - y_0) = (x_2 - x_0)\ (y_E - y_3)$, etc. Cancellation of these equalities from Equation 6 gives

$$\frac{(y_1-y_0)\ (x_E-x_q)}{(y_E-y_1)\ (x_q-x_0)} = \left(\frac{y_0x_E}{x_0y_E}\right)^{n_1} \quad (7)$$

which is a general equation for calculating the number of plates above the feed plate.

For conditions below the feed plate the equilibrium curve is extended below the origin to permit intersection with the stripping line at points (x'_E, y'_E) and (x'_0, y'_0). A rectangle is constructed with these points on the diagonal. The derivation of the equation for the number of plates below the feed plate is entirely analogous to that given and result in the equation

$$\frac{(y_q-y'_0)\ (x'_E-x_w)}{(y'_E-y_q)\ (x_w-x'_0)} = \left(\frac{y'_0x'_E}{x'_0y'_E}\right)^{n_2} \quad . . . . . (8)$$

The total number of plates required for the entire column is the sum of n_1 and n_2 where n_2 includes the still pot as one of the plates in the stripping section.

Equations 7 and 8 are algebraically identical to those proposed by Smoker, although the similarity is by no means obvious. When this derivation is applied to conditions at total reflux, the equation reduces to

$$y_1(1-x_w)/x_w(1-y_1) = a^n,$$

as given by Fenske.

Nomenclature

- x = mole fraction of more volatile component in liquid,
- y = mole fraction of more volatile component in vapor,
- y_1 = mole fraction of more volatile component in overhead product,
- x_w = mole fraction of more volatile component in waste,
- a = relative volatility,
- m = slope of rectifying line,
- c = y-intercept of rectifying line on x, y diagram when $x = 0$,
- x_0, y_0 = lower point of intersection of rectifying line and equilibrium curve,
- x_E, y_E = upper point of intersection of rectifying line and equilibrium curve,
- x'_0, y'_0 and x'_E, y'_E = lower and upper points of intersection of stripping line and equilibrium curve, respectively,
- x_q, y_q = point of intersection of rectifying and stripping lines,
- y_q' = equilibrium value of y when $x = x_q$,
- n_1 = number of theoretical plates for rectifying section,
- n_2 = number of theoretical plates for stripping section.

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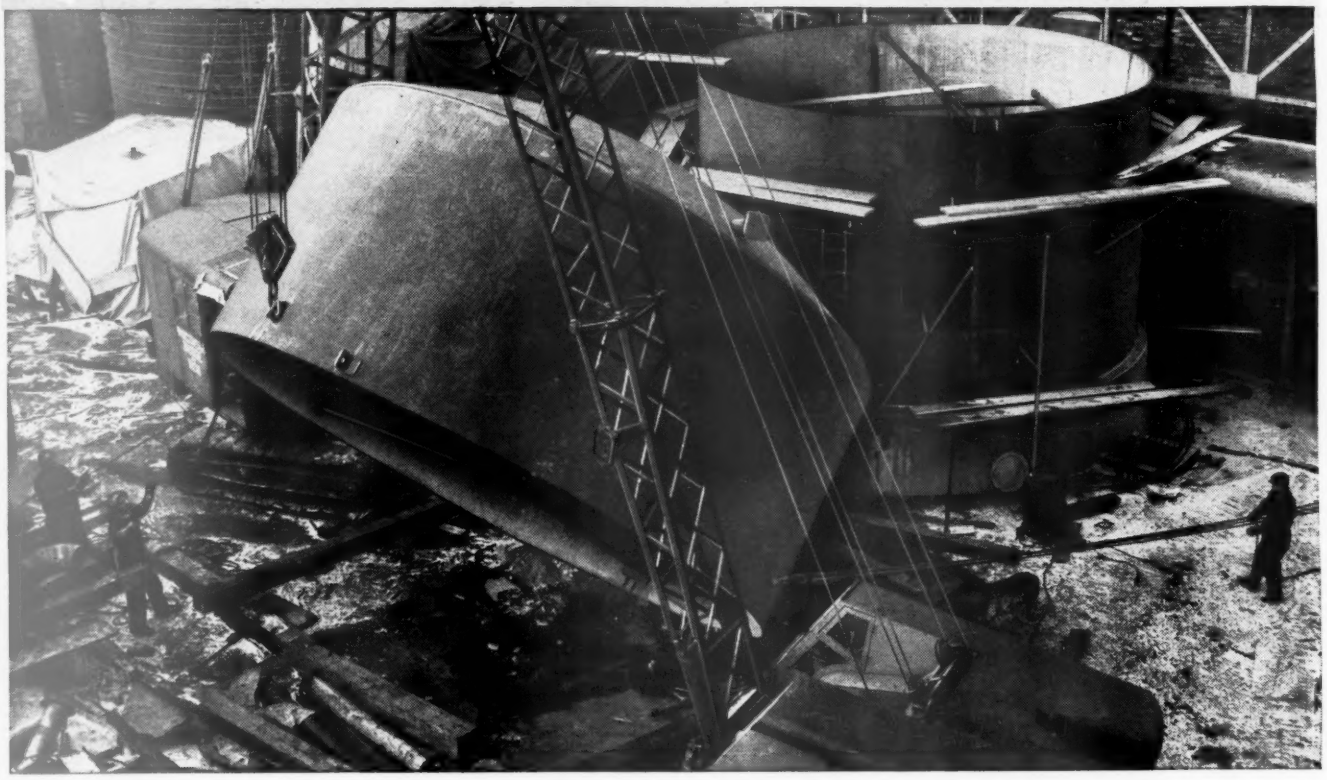

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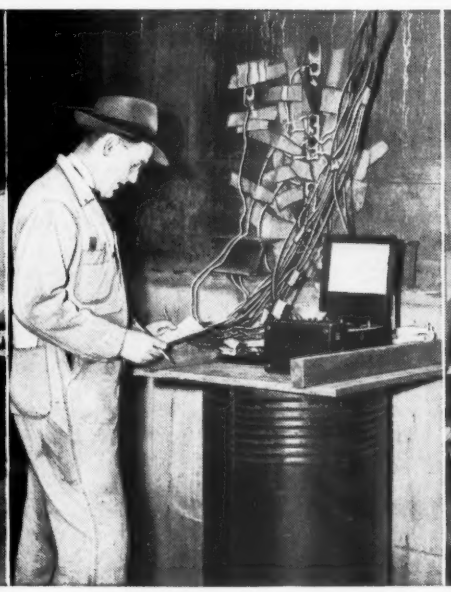

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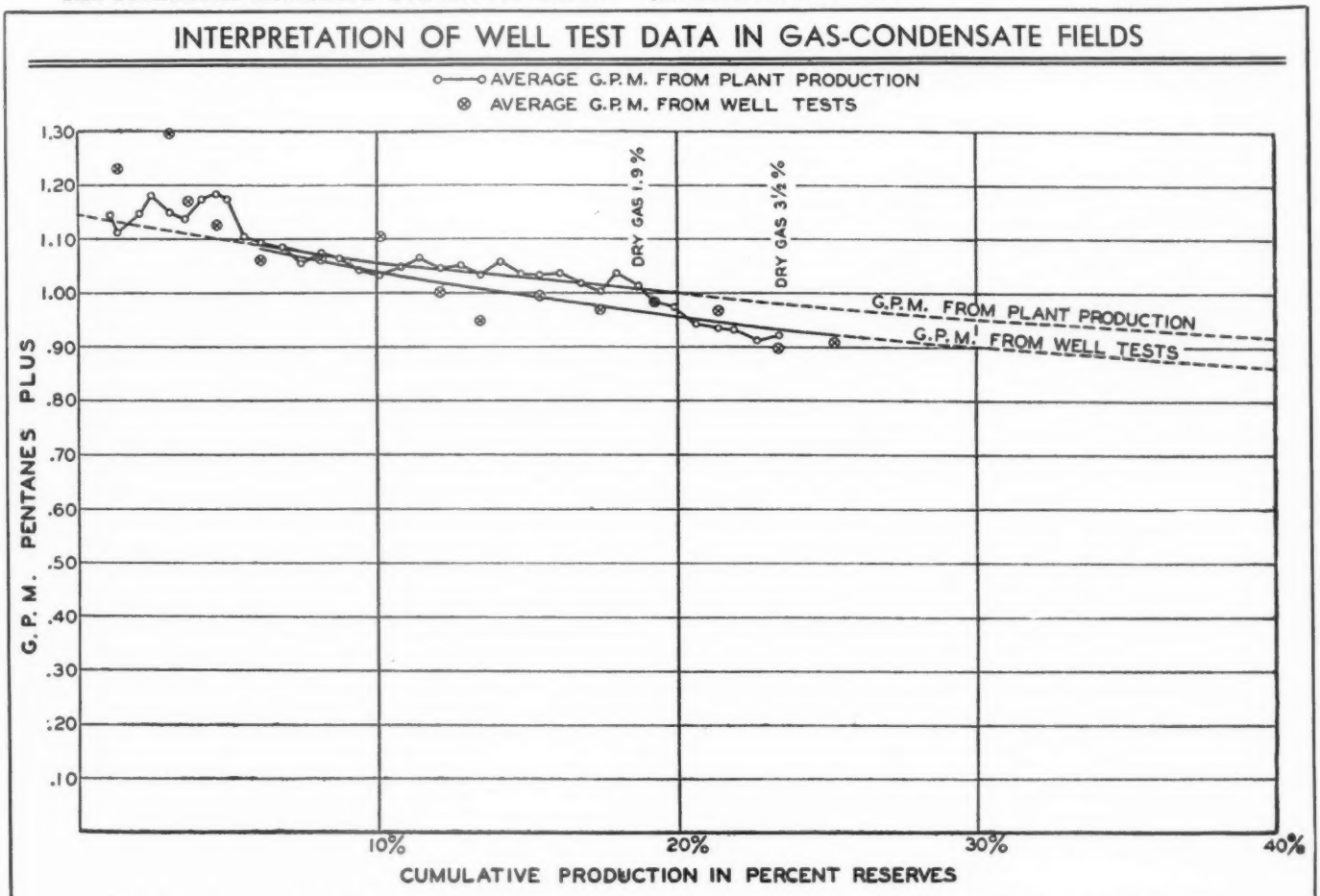

FIG. 14. Comparison of average G.P.M. records from plant production and well tests, LaGloria field, Texas.

● **Comparisons of field with laboratory retrograde losses.** The industry has proceeded necessarily on the assumption that retrograde laboratory tests were analogous to underground conditions, and that such tests would provide data reliable enough to be used in predicting losses to be expected in the reservoir. It has been realized that the effects of the enormous surface areas of the reservoir pores were not duplicated in the laboratory, but it has been thought that agitation in the cell would give the same results. It has also been realized that perhaps the cells did not simulate some of the other conditions in the reservoir that might be important. It has been obvious that only from comparison with field data could it be known how valid was the assumption of similarity between laboratory and reservoir conditions.

From the preceding discussions, the difficulties in checking laboratory against field data are apparent. To make valid comparisons, it must be assured that the two sets of data apply to the same gas and to the same conditions. With respect to the determination of the retrograde behavior of the gas in the laboratory, the following are the considerations:

1. That the tests are made on representative reservoir samples at reservoir temperatures.
2. Whether differential or flash separation should be used or something in between.
3. The test data should represent the same hydrocarbon composition as the field data.
4. The cumulative losses should be converted to rate losses.

With respect to the field tests of the gas from the producing wells, the following are the considerations:

1. Reliable sampling of the wells and of the reservoir.
2. The samples must be from uncontaminated wells, which originally had the same composition as the test samples.
3. The samples must be accurately analyzed.
4. It must be determined whether comparison is to be made at flowing or bottom-hole pressures, or at some intermediate pressure.

Fig. 14 compares the weighted averages obtained in the two ways in the La Gloria field, both showing pentanes plus. From these records it is evident that there is a persistent difference in trend between the two and that the well tests showed more than the true content during the first few months of operation and less in later months. However, the smoothed curves are never more than 5 per cent apart. The graphs show that all the well tests deviate in one direction or the other at certain test periods. There is some evidence that well tests show higher content in winter than in summer. The plant production record appears to fit a logarithmic curve.

In the Stratton-Agua Dulce field, the records of three plants show less consistent deviations. The comparable parts of the records show the data given in Table 1.

The plant record itself can be used as the average where it has been operating under reasonably uniform conditions; that is, taking gas from the same wells at nearly the same rates while the plant meanwhile extracts the same products. A 21-month period reasonably well satisfies these requirements for the La Gloria plant. In the early months of operations one well that produced some oil caused the high content shown in Fig. 14, but after it was taken off production, field and plant operations were nearly uniform until dry gas began to invade some of the wells in important quantities. The smaller irregularities are caused principally by minor changes in plant operation and well production. Unfortunately, no retrograde tests have been made on the gas from the La Gloria field to compare with this record.

Taken from the article, "Interpretation of Well Test Data in Gas-condensate Fields," by James O. Lewis that was presented before American Institute of Mining and Metallurgical Engineers, Chicago, Illinois, February 1946. Published in *Petroleum Technology*, July, 1946. Published in *The Petroleum Engineer*, September, 1947, pages 180 to 202, inclusive.

NOTE: References are shown on the last sheet in this series of tables.

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PLATE EFFICIENCY OF FRACTIONATING COLUMNS AND ABSORBERS

TABLE 3. Tests conducted at Ethyl Corporation, Baton Rouge, Louisiana.

Test No. 1

Stabilization of ethylene dichloride

Number of plates	7
Plate spacing	18 in.
Column diameter	30 in.
Feed plate	top plate
Feed flow	90.7 moles/hr
Overhead flow	35.6 moles/hr
Bottoms flow	55.1 moles/hr
Feed temperature	116 F
Top temperature	214 F
Bottom temperature	230 F
Column pressure	27.5 psia
Heat supplied in reboiler	808,000 Btu/hr
Heat removed in overhead condenser	570,000 Btu/hr

Component	Feed*	Bottoms*	Overhead*
Ethane	0.0188	.....	0.0300
Ethyl chloride	0.0157	0.0001	0.0400
Water	0.0138	0.0003	0.0346
Ethylene dichloride	0.9504	0.9975	0.8949
Trichloroethane	0.0013	0.0021	0.0005

*Mole fraction.

Theoretical plates required for water-ethylene dichloride separation†	2
Plate efficiency for water-ethylene dichloride separation (2/7) (100), per cent	29
Theoretical plates required for ehtyl chloride-ethylene dichloride separation†	4
Plate efficiency for ethyl chloride-ethylene dichloride separation (4/7) (100), per cent	57

†Calculated by method of Sorel.[30] Equilibria data for systems water-ethylene dichloride and ethyl chloride-ethylene dichloride obtained from unpublished data from Ethyl Corporation.

Test No. 2

Stabilization of ethylene dichloride

Number of plates	7
Plate spacing	21 in.
Column diameter	24 in.
Feed plate	top plate
Feed flow	76.3 moles/hr
Overhead flow	22.1 moles/hr
Bottoms flow	54.2 moles/hr
Feed temperature	57 F
Top temperature	189 F
Bottom temperature	207 F
Column pressure	6 psig
Heat supplied in reboiler	708,000 Btu/hr
Heat removed in overhead condenser	328,990 Btu/hr

Component	Feed*	Bottoms*	Overhead*
Water	0.0065	0.0001	0.0221
Ethylene dichloride	0.9935	0.9999	0.9779

*Mole fraction.

Theoretical number of plates required for separation	2
Plate efficiency (2/7) (100), per cent	29

Test No. 3

Stabilization of ethylene dichloride

Number of plates	24
Plate spacing	18 in.
Column diameter	30 in.
Feed plate	top plate f
Feed flow	196.7 moles/hr
Overhead flow	86.1 moles/hr
Bottoms flow	110.6 moles/hr
Feed temperature	—24 F
Top temperature	142 F
Bottom temperature	203 F
Column pressure	136 psig
Heat supplied in reboiler	1,600,000 Btu/hr

No overhead condenser.

Component	Feed*	Bottoms*	Overhead*
More volatile than isobutane	0.1901	<0.00001	0.4342
Isobutane	0.0593	0.001	0.1354
Ethyl chloride	0.7506	0.999	0.4304

*More fraction.

Number of theoretical plates required for separation isobutane-ethyl chloride†	20 5
Plate efficiency (20.5)/(24) (100), per cent	85

†Equilibria data for system isobutane-ethyl chloride obtained from unpublished data from Ethyl Corporation.

The determination of the number of theoretical plates requires accurate vapor-liquid equilibria data. In many cases, especially in multicomponent mixtures such data are not available and are difficult to obtain. For example, the equilibrium vaporization constant ($K = y/x$) which are available for hydrocarbons are in some cases a function of the composition of the liquid and the critical properties of the mixture as well as the temperature and pressure of the system. Such factors must be taken into account in the calculation of the number of theoretical plates required.

● **Acknowledgment.** The test data in Table 3 were obtained by E. P. Breidenbach, H. M. Rodekohr, T. M. Smylie, H. H. Wall, and P. R. Walton of the development section of Ethyl Corporation. The data were compiled and the graphs prepared by Rose E. Worsham. The author wishes to acknowledge with thanks the critical review of the report by O. E. Kurt, F. A. McCoy and F. J. Sergeys.

First published in the August, 1946, Transactions of the American Institute of Chemical Engineers and reprinted by permission of the publishers in *The Petroleum Engineer*, Reference Annual, 1947, pages 200 to 210 inclusive. H. E. O'Connell, Ethyl Corporation, is the author.

● **Nomenclature.**

μ = viscosity, centipoises,

H = Henry's law constant in lb moles per cu ft atm,

P = pressure in atmospheres,

α = relative volatility,

$(PTU)_{ov}$ = number of plates equivalent to a transfer unit,

E = overall plate efficiency,

E_{mv} = Murphree plate efficiency = $Y'_1 - Y'_o / Y'_1 - Y'^*$,

E_{pv} = point plate efficiency,

Y'_1 = mole fraction of more volatile component in the vapor phase of the total vapor entering the plate,

Y'_o = mole fraction of more volatile component in the vapor phase of the total vapor leaving the plate,

Y'^* = mole fraction of more volatile component in the vapor phase in equilibrium with the liquid leaving the plate.

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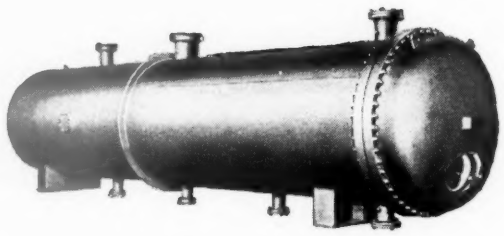

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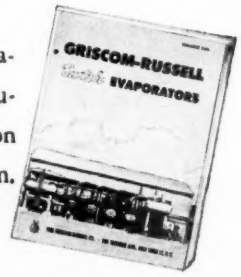

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INTERPRETATION OF WELL TEST DATA IN GAS-CONDENSATE FIELDS

In Fig. 15 are shown the smoothed averaged G.P.M. curves for three groups of wells in the Stratton-Agua Dulce field. The average G.P.M. is plotted against time, but as each group of wells was produced at nearly uniform rates, the time scale is nearly proportional to the pressure loss. All three records plot as straight lines on logarithmic paper by adding constants to the time scale. Curve A is the average of seven shallow wells in sands that were being cycled. Curve B is the average of 26 deeper wells in sands that were being cycled, and curve C is the average of six wells of nearly the same depth as for curve B but in sands that were not being cycled. The more significant facts respecting the three groups of wells are given in Table 2.

Retrograde tests by flash separation were made on wells that fairly well represented the shallow and deeper groups of wells. The shallower wells showed a maximum average loss of 0.24 G.P.M. and the deeper wells 0.45 G.P.M., both on the cumulative basis and including solution gas.

The comparative behaviors of the three groups of wells are not what could be expected from the retrograde tests. The wells with the lean gases have shown approximately the same G.P.M. loss as the wells with richer gases although the pressure loss has been much less for the shallow wells. The wells not in cycled sands have had less G.P.M. loss than the wells in cycled sands although the initial G.P.M. was the same for each and although the wells in uncycled sands had suffered more pressure loss.

When the retrograde curves are computed to the rate basis and compared with the three curves in Fig. 15, the actual losses for the shallow wells are found to be so much greater than shown by the retrograde tests that they cannot be reconciled. The actual losses for the 26 deeper wells in cycled sands also are greater than shown by the retrograde tests and would be still greater if allowances were made for solution gas and for liquid flow of condensates into the wells, but it cannot be said positively but what more accurate data could not reconcile them. The rate of losses for the six deeper wells in uncycled sands are less than shown by the retrograde tests, but allowing for solution gas and inaccuracies they could reasonably be reconciled.

Too much significance should not be attached to the lower losses shown by the wells in uncycled sands because under depletion the bulk of the gas in the reservoirs will go through lower pressures and be subjected to much more severe retrograde conditions than in a cycled reservoir; hence their ultimate losses by condensation and retention can reasonably be expected to be greater than if cycled. However, the field data available to the writer give no basis for estimating how much more loss would be suffered.

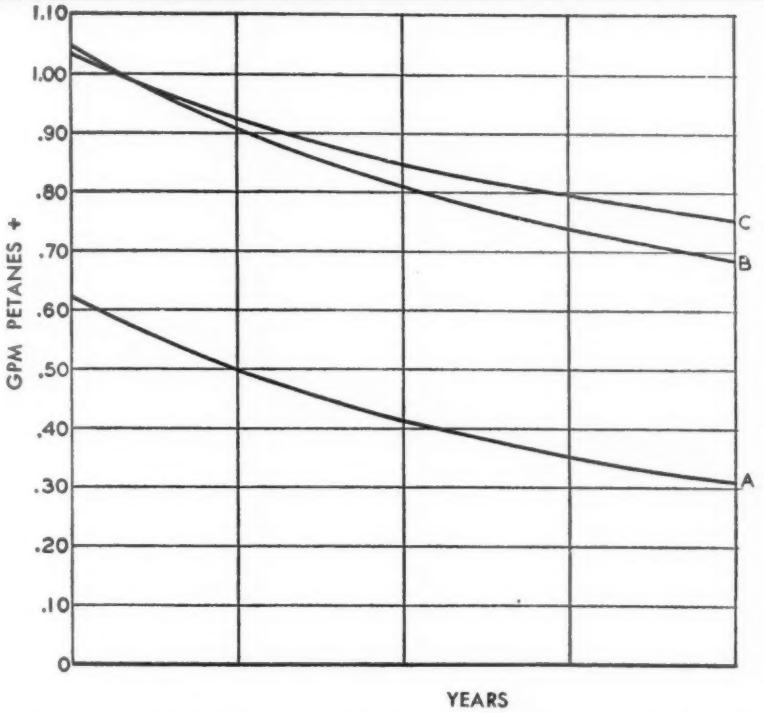

FIG. 15. Average G.P.M. curves for 3 conditions in Stratton-Agua Dulce field.

A. Average of 7 shallow wells in cycled reservoirs containing lean gases.
B. Average of 26 deeper wells in cycled reservoirs containing richer gases.
C. Average of 6 deeper wells in reservoirs not being cycled and containing richer gases.

Though these comparisons of laboratory with field data are unsatisfactory and inconclusive, there is enough evidence to throw some doubt upon the assumption that laboratory methods are fully analogous to reservoir conditions. On the whole, the evidence indicates that cycling is effective to a lesser degree in preventing retrograde losses than has been assumed. The writer suspects that the causes of dissimilarities between field and test data may be found in the pressure sinks formed around each flowing well. However, to reach valid conclusions with respect to the applicability of laboratory to actual conditions, it will be necessary to have more accurate data from more fields than were available to the writer, and the laboratory data will have to be presented in comparable terms.

TABLE 1. Records of three plants, Stratton-Agua Dulce field.

Plant	Average well G.P.M.	Plant G.P.M.	Difference, per cent
Wardner	0.828	0.870	+5
Coastal	0.790	0.812	+3
Gulf Plains	0.831	0.815	−2
Averages	0.816	0.832	+2

TABLE 2. Three groups of wells in Stratton-Agua Dulce field.

Averages	A	B	C
Initial pressures, psi	2,250	3,030	3,150
Initial G.P.M.	0.62	1.05	1.04
Loss in G.P.M., in 4 years	0.31	0.36	0.28
Percentage loss in 4 years	50	34.5	27
Loss in static bottom-hole pressure, psi	170	410	500
Loss to flowing bottom-hole pressure, psi	280	500	670

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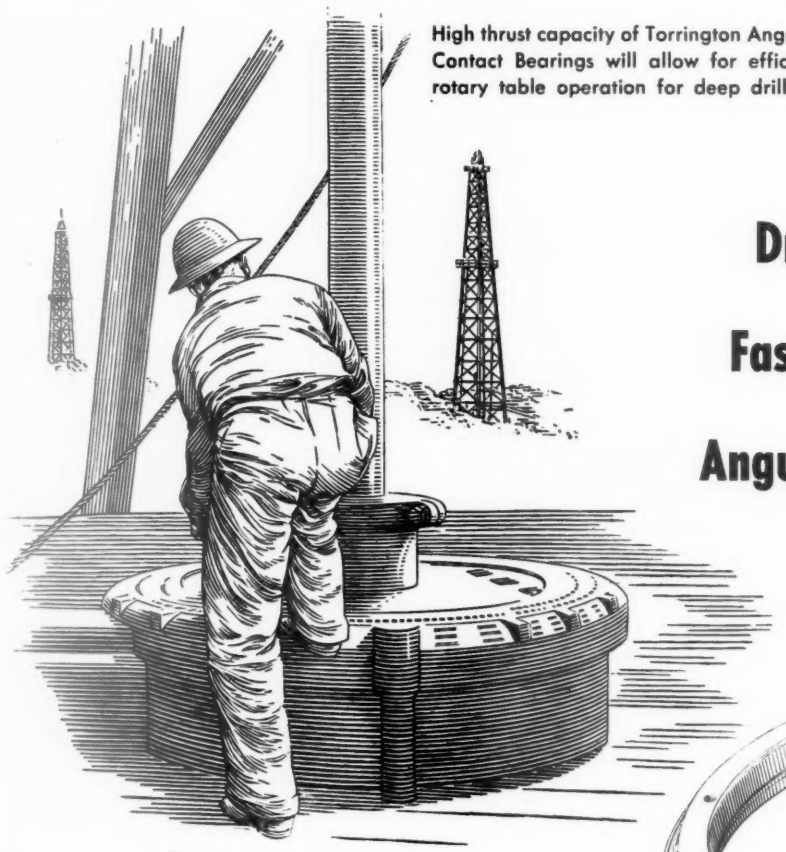

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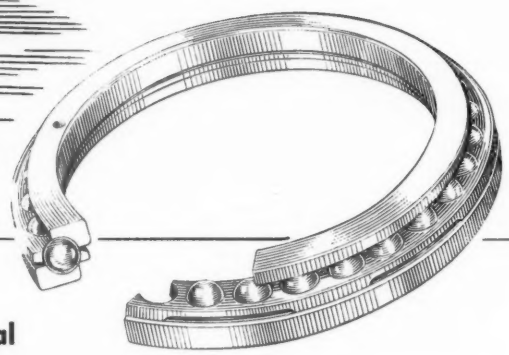

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USE OF LOG-LOG PLOTS OF McCABE-THIELE DIAGRAMS IN FRACTIONATION PROBLEMS

● **Construction.** Fig. 1 shows a log-log plot of the McCabe-Thiele diagram for solving a fractionation problem on the water-n-butane system. Plotting the operating line on log-log paper requires several points in contrast to the one point, $y = x = x_D$, and the slope L/V needed for rectangular paper. The additional points, however, can be determined easily from the usual equations of the operating lines. Plates are numbered from top to bottom of column in the following discussion.

Upper operating line:

$$y_{n+1} = \frac{Lx_n}{V} + \frac{Dx_D}{V} \quad . \quad . \quad . \quad (1)$$

Where:

D = mols of overhead product,
L = mols of liquid from plate n in rectifying section,
V = mols of vapor from plate n + 1 in rectifying section,
X_D = mol fraction of more volatile component in overhead product,
x_n = mol fraction of more volatile component in liquid from plate n in rectifying section, and
y_{n+1} = mol fraction of more volatile component in vapor from plate n + 1 in rectifying section.

Lower operating line:

$$y_m = \frac{\bar{L}x_{m-1}}{\bar{V}} + \frac{Bx_B}{\bar{V}} \quad . \quad . \quad . \quad (2)$$

Where:

B = mols of bottom product,
$\bar{L}$ = mols of liquid from plate m—1 in stripping section,
$\bar{V}$ = mols of vapor from plate m in stripping section,
x_B = mol fraction of more volatile component in bottom product,
x_{m-1} = mol fraction of more volatile component in liquid from plate m—1 in stripping section, and
y_m = mol fraction of more volatile component in vapor from plate m in stripper section.

Several values of y calculated for the corresponding values of x from equations (1) and (2) should be sufficient to plot both operating lines.

Problem. Determine the number of theoretical plates required to reduce the water content of n-butane to a mol fraction of 1×10^{-6}. The n-butane feed to the column is saturated with water at 100 F. Assume the column will operate with a vapor load equal to 10 per cent of the feed to the column.

Solution. If n-butane is saturated with water at 100 F, it will contain 0.05 mol per cent water according to Sage et al. As the composition of the n-butane leaving the bottom of the column must equal 1×10^{-4} mol per cent, the amount of water removed from the top of the column will equal, for all practical purposes, the amount of water entering in the feed. Assume that the accumulator temperature is 100 F. With this information, the following material balance around the column can be determined.

Basis: 100 mols of feed

Mols of water in feed = $Fx_F = 100\ (0.0005) = 0.05$ mol.

Mols of water in bottoms = $Bx_B = 99.95\ (1 \times 10^{-6}) = 0.00009995$ mol.

Assuming constant vapor load through column:

$V = \bar{V} = 0.10\ (100) = 10$ mols.

Reflux = V—D = 10—0.05 = 9.95 mols.

A material balance around the accumulator yields:

$$Vy_1 = Rx_R + Dx_D \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Where:

R = mols of reflux,
x_R = mol fraction of more volatile component in reflux, and
y_1 = mol fraction of more volatile component in vapor from top plate.

If the accumulator temperature is taken as 100 F:

$x_R = 0.0005$

which is the saturated value[a] at 100 F.

$$y_1 = \frac{9.95\ (0.0005)}{10} + \frac{0.05\,(1.0)}{10} = 0.0055.$$

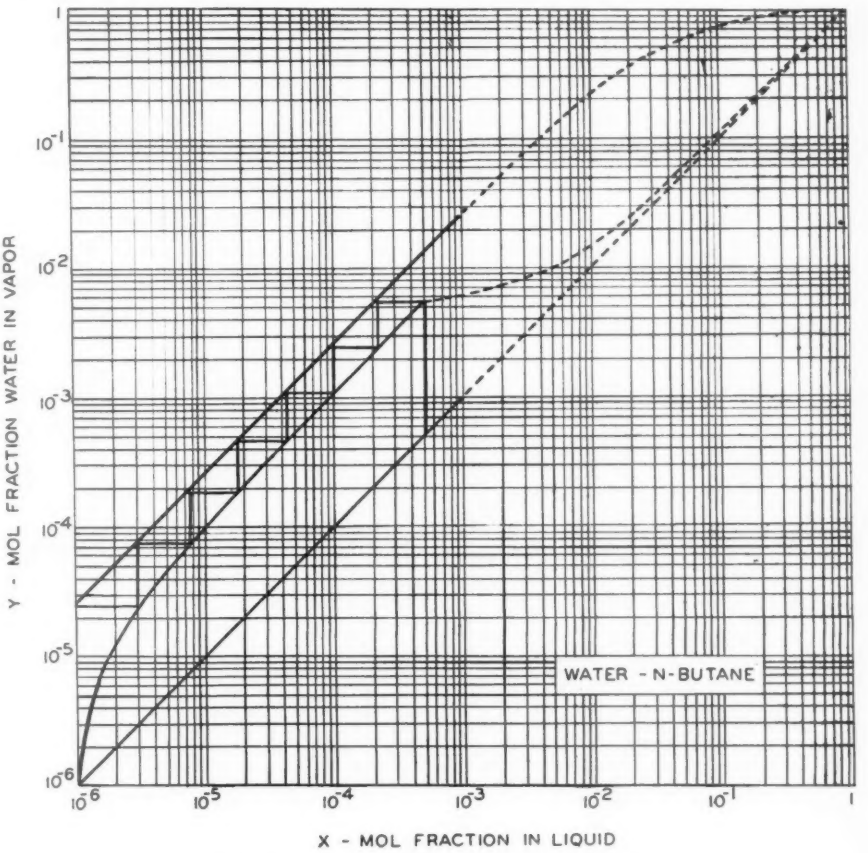

FIG. 1. Log-log plot of McCabe-Thiele diagram.

Certain assumptions are necessary because complete data on the water-n-butane system are not available. Constant relative volatility is assumed over the range of operating temperatures in the column (approximately 3 F). This yields the following equation for the equilibrium curve:

$$y = \frac{\alpha x}{(\alpha - 1)\,x + 1} \quad . \quad . \quad . \quad . \quad (4)$$

Where α = relative volatility constant.

From data of Sage et al the value of α was determined as 25.3 with water being the more volatile component. The equilibrium curve determined by equation (4) appears in Fig. 1. Both the equilibrium curve and upper operating line have been dashed above a liquid composition of 0.1 mol per cent since two liquid phases would be present and the McCabe-Thiele diagram would not apply in this region.

Stepping off the theoretical plates in Fig. 1 shows that less than one theoretical plate is necessary to rectify the overhead vapors to 0.55 mol per cent water. Seven theoretical plates are necessary in the stripping section to reduce the water content to 1×10^{-4} mol per cent water. Therefore, the feed to the column should enter the top plate.

Taken from the exclusive article, "Application of the log-log plot to fractionation problems," by Frank C. Fowler, published in *The Petroleum Engineer*, September, 1947, pages 57 and 58.

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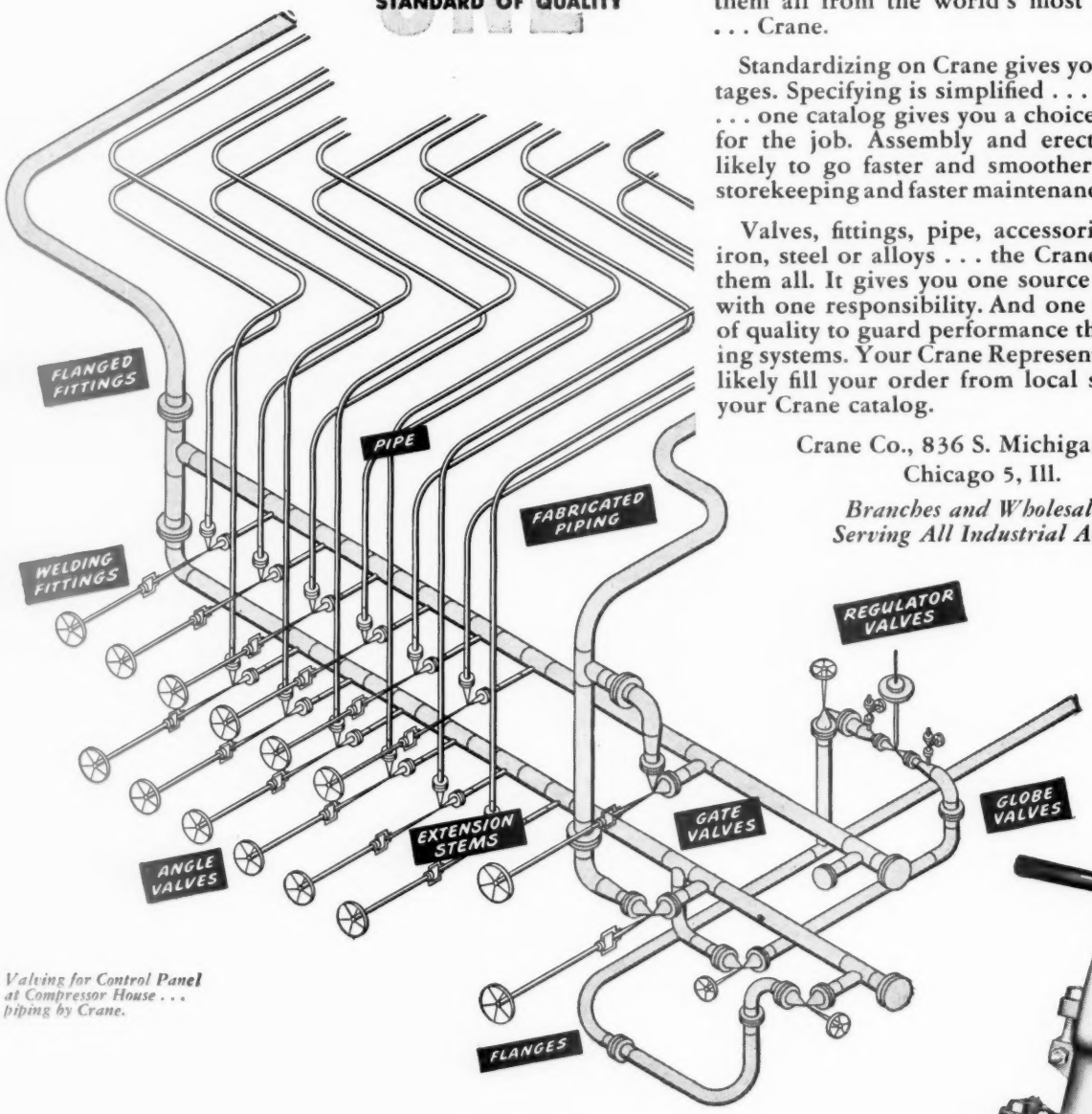
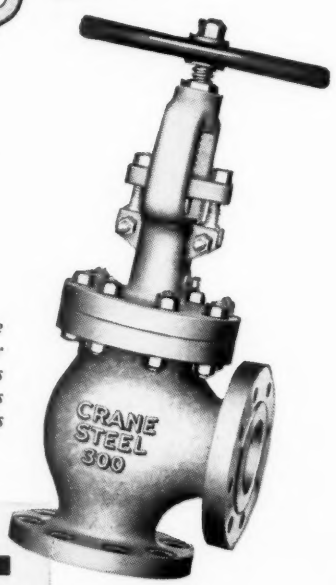
Serving All Industrial Areas



Valving for Control Panel at Compressor House . . . piping by Crane.



RUGGED AND SUBSTANTIAL *for refinery services, Crane Cast Steel Globe and Angle Valves, for 300 pounds oil or oil vapor. Crane meets your specifications in all steel valves . . . gates, globes, angles, checks . . . in pressure classes from 150 to 2500 pounds . . . with proved trim materials for all services. Flanged, screwed or welding ends.*

EVERYTHING FROM . . .

VALVES • FITTINGS
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AND HEATING

CRANE

FOR EVERY PIPING SYSTEM

Division chief engineer

Appointment of William J. Redman as division chief engineer of the Wilson-Snyder Manufacturing Division of Oil Well Supply Company, Braddock, Pennsylvania, was announced by the U. S. Steel subsidiary.

W. J. Redman

A native of Pittsburgh, Redman attended the University of Pittsburgh and Carnegie Institute of Technology. He started with Oil Well Supply at the Wilson-Snyder plant in 1923 as a draftsman. He was appointed assistant chief engineer in 1942, holding that position until his present appointment.

H. G. Smith promoted

Harry G. Smith has been elected vice president and general manager of Smith Meter Company, Los Angeles, California, according to announcement received from the company. Starting ten years ago in their engineering research division, Smith has successively held the positions of western sales manager and general sales manager.

Harry G. Smith

Department expands

C. E. (Bert) Huff, general sales manager of the Special Products Division of Black, Sivalls and Bryson, Inc., announces the reorganization and expansion of the Foundry Equipment Department. The program began February 1, when C. W. (Joe) Boettcher was assigned to the job of handling quotations on special equipment and of expediting production through the plant. At the same time, C. C. (Charlie) Zircher was given the job of handling the processing of orders and of keeping statistics on sales and shipments.

Production changes were also instituted in Black, Sivalls and Bryson's Kansas City plant to speed the manufacturing of all-welded steel foundry flasks and allied equipment.

Organize divisions

The organization of six divisions in the small and medium motor divisions of the General Electric Company was announced by W. H. Henry, manager of the divisions, which constitute one of the major new businesses recently formed by the G-E Apparatus Department. The new business has been organized by Henry into six major divisions—administrative, general sales, product sales, product engineering, product manufacturing, and accounting.

D. E. Moorhead was named assistant to the manager of the divisions, assigned to engineering and manufacturing work.

O. F. Vea was appointed assistant to the manager of the divisions, assigned to sales work. He was also named manager of the marketing and promotion division in the general sales divisions.

H. W. Bennett was named manager, gear motor sales divisions.

C. W. Falls was appointed manager, commercial engineering division, general sales divisions.

J. T. Farrell was made manager, d-c motor sales division, product sales divisions.

Elliott Harrington was named manager, induction motor sales division, product sales divisions.

C. C. Hutton, was appointed accountant, Schenectady induction motor accounting division.

M. E. Rexford was made manager, standards and pricing division, general sales divisions.

Other men named were L. D. Fowler, manager Oakland motor sales division, Oakland, California; L. E. Sproul, accountant, Lynn motor accounting division, Lynn, Massachusetts, and D. A. Yates, manager, Lynn motor sales division, Lynn.

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LIQUID GRAVITOMETER
...for PIPELINES, REFINERIES, GASOLINE PLANTS
This ruggedly built instrument of laboratory accuracy is ideal for quick checking and for continuous recording of Specific Gravity of liquids under line pressure. Changes in Specific Gravity of sample are recorded with a very minimum of time lag. Foreign liquids and gases are automatically purged from sample. No moving joints or stuffing boxes to cause friction or leakage. Temperature corrected, this precision instrument is adaptable to high pressures. Hundreds are in daily use in plants and refineries of major companies.
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Firm incorporates

The former partnership of Vaughn and Taylor, Wichita Falls, Texas, engaged in pipe line construction in the Mid-Continent area, received charter of corporation from the Texas secretary of state on November 25, and is now operating as Vaughn and Taylor Construction Company, Inc. Officers of the new corporation as elected by the first meeting of directors are as follows: D. D. Vaughn, president; R. L. Taylor, first vice president; Jess Moore, second vice president; H. B. May, third vice president, and T. D. Vaughn, secretary and treasurer.

Offices are at 827-828 Hamilton Building, Wichita Falls, Texas, and permanent warehouses are at Wichita Falls and Dumas, Texas. Billie Hallmark is bookkeeper for the firm.

Receives award

Fifty-eight employes of the General Electric Company and its manufacturing affiliates, who performed work of outstanding merit during the years 1946 and 1947, received Charles A. Coffin awards for their accomplishments, it was announced by Charles E. Wilson, G-E president.

Named for the first president and one of the founders of the General Electric Company, the Charles A. Coffin awards, the company's highest, carry a certificate and a cash honorarium. In the latest awards, the company divided $14,500, or $250 per person, among those cited.

The awards provide recognition by the company of accomplishments of unusual merit by employes engaged in all types of work.

Heads new office

Link-Belt Company announces that it has established a sales office in Louisville, Kentucky, with headquarters at 136 South Fourth Street. Emmart LaCrosse, Jr., formerly district sales engineer at Indianapolis, has been appointed district sales manager in charge of the new office.

LaCrosse entered Link-Belt employ in 1937 at the Pershing Road plant, Chicago, serving subsequently at the company's Dallas plant, the Cleveland branch office, and, since 1941, at the Indianapolis branch.

He will be assisted by Herschel O. Smith, who has been associated with Link-Belt since 1937, except for four years in the Armed Services.

Heywood promoted

H. E. Heywood, a veteran of 35 years in the oil industry, has been appointed manager, general sales office, of The National Supply Company at Toledo, Ohio. He will assist in the overall operation of the sales office and continue supervision of the inventory control department.

Heywood joined The National Supply Company in 1923, taking charge of the East Tulsa Warehouse and later became manager of the Tulsa store. He was assistant purchasing agent at Tulsa 1931-39 and was named manager of inventory control at Toledo in 1940.

Exploration firm elects

At the first stockholders meeting recently of Marine Exploration Company, Houston, Texas, A. B. Hamil, 4211 Childress Boulevard, was elected president and two members of a Houston law firm were named consultants.

Officers of Marine Exploration in addition to Hamil are Gordon M. Mace, Jr., vice president in charge of interpretative analysis; R. W. Upshaw, vice president in charge of field operations; Mrs. Ferne Hamil, secretary-treasurer, and Miss Bette Muir, assistant secretary-treasurer.

Charles R. Hrdlicka was appointed attorney for the corporation and B. Hunter Loftin was appointed tax consultant for the corporation. Both are members of the firm of Butler, Binion, Rice and Cook.

A. B. Hamil, the president, was formerly foreign and domestic supervisor for the Petty Geophysical Engineering Company of San Antonio, Texas, geophysicist and supervisor for Rogers-Ray, Inc., Houston, and National Geophysical Company, Inc., Dallas, and a partner in the National Geophysical Drilling Company, Dallas.

Gordon M. Mace, Jr., vice president, was also employed by Petty Geophysical

Engineering Company in Sumatra, Dutch East Indies, South America, and the various domestic oil producing states.

R. W. Upshaw, vice president, was formerly a technician with the Petty Geophysical Engineering Company and Rogers-Ray, Inc., and was in charge of various marine surveys for the National Geophysical Company, Inc.

Marine Exploration Company was organized to perform specialized marine seismic surveys with specially designed and constructed compact waterproof seismic instruments and auxiliary surveying and drilling equipment in the swamp, marsh, and water regions of the Gulf Coast area and foreign areas of inaccessibility. The company has also provided special equipment for the rugged terrain of the Rocky Mountain district of the United States.

Directional drilling project

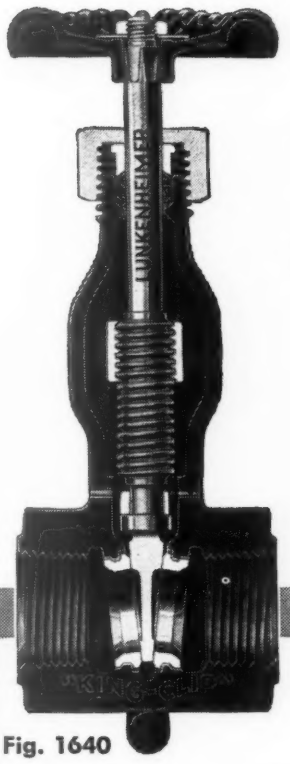
A directional drilling project of unusual proportions was recently undertaken by the Houston Oil Field Material Company for the Creole Petroleum Corporation in Venezuela. The directional drilling tools and operators were flown to South America by a chartered DC-3 plane of the Pioneer Airlines, Inc. The tools, weighing approximately 5000 lb, were loaded in Houston and the operators, E. B. (Eddie) Hearn and C. M. (Mack) Standridge, were picked up at New Iberia, Louisiana. The port of embarkation for the plane was Miami, Florida, with refueling stops at Nassau, Puerto Rico, and Trinidad. The destination was Maturin, Venezuela.

The tools required for the job consisted of miscellaneous sizes of whipstocks and bits, reamers, K-monel subs, small orienting subs, bottom hole surveying instruments, and all the necessary extra parts. The project consists of directional drilling a number of wells in the Tucupita area of Venezuela and will be supervised by alternate crews of directional drilling engineers from the Houston Oil Field Material Company.

O. B. Wilson manager

O. B. Wilson has been named industrial manager for the eastern sales region of the Brown Instrument division of Minneapolis-Honeywell Regulator Company. Wilson's promotion makes him regional manager of the territory extending from northern Virginia, through eastern Pennsylvania, to the Canadian border, west to Rochester, New York, and in New England.

Wilson has been with the Honeywell-Brown organization for the last 25 years. He has served as a sales engineer in various parts of the country and has been industrial manager in Houston, Chicago, and New York. He will continue to make his headquarters in New York City where he has been the Brown manager for the last two years.



YOUR VALVE DOLLAR
Goes Farther—
with LUNKENHEIMER "KING-CLIP" VALVE

Fig. 1640

The Lunkenheimer "King-Clip" Valve has one quality feature after another... from the coarse, heavy stuffing box threads and hex-head gland which minimize stuffing box troubles... to the heavy body which resists wrenching and piping strains... and the heavy rust-proofing treatment, inside and out. Each feature adds longer life, lower maintenance and better service, wherever small and medium sized gate valves are used.

Note the ample, unobstructed drain channels and bronze thread bushing, features originated by Lunkenheimer, as was the "King-Clip" Valve itself. The Lunkenheimer "King-Clip" Valve is truly the king of all clip type valves... widely used for more than 50 years and, today, better than ever for longer, low-cost service.

ESTABLISHED 1862
THE LUNKENHEIMER CO.
—"QUALITY"—
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BOSTON 10 · PHILADELPHIA 34
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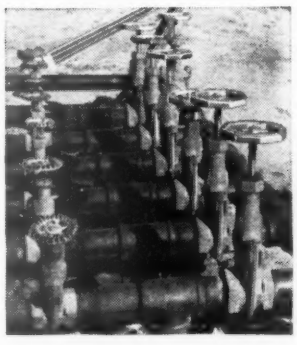


Manifold employing multiple Lunkenheimer "King-Clip" Gate Valves. Note the compactness of the installation and the convenience of the bolted bonnets, each of which is readily accessible. "King-Clip" Gate Valves are furnished in 21 standard types, with iron body-bronze trim, all-iron or iron body-alloy trims and with inside or outside rising stems for various service needs.

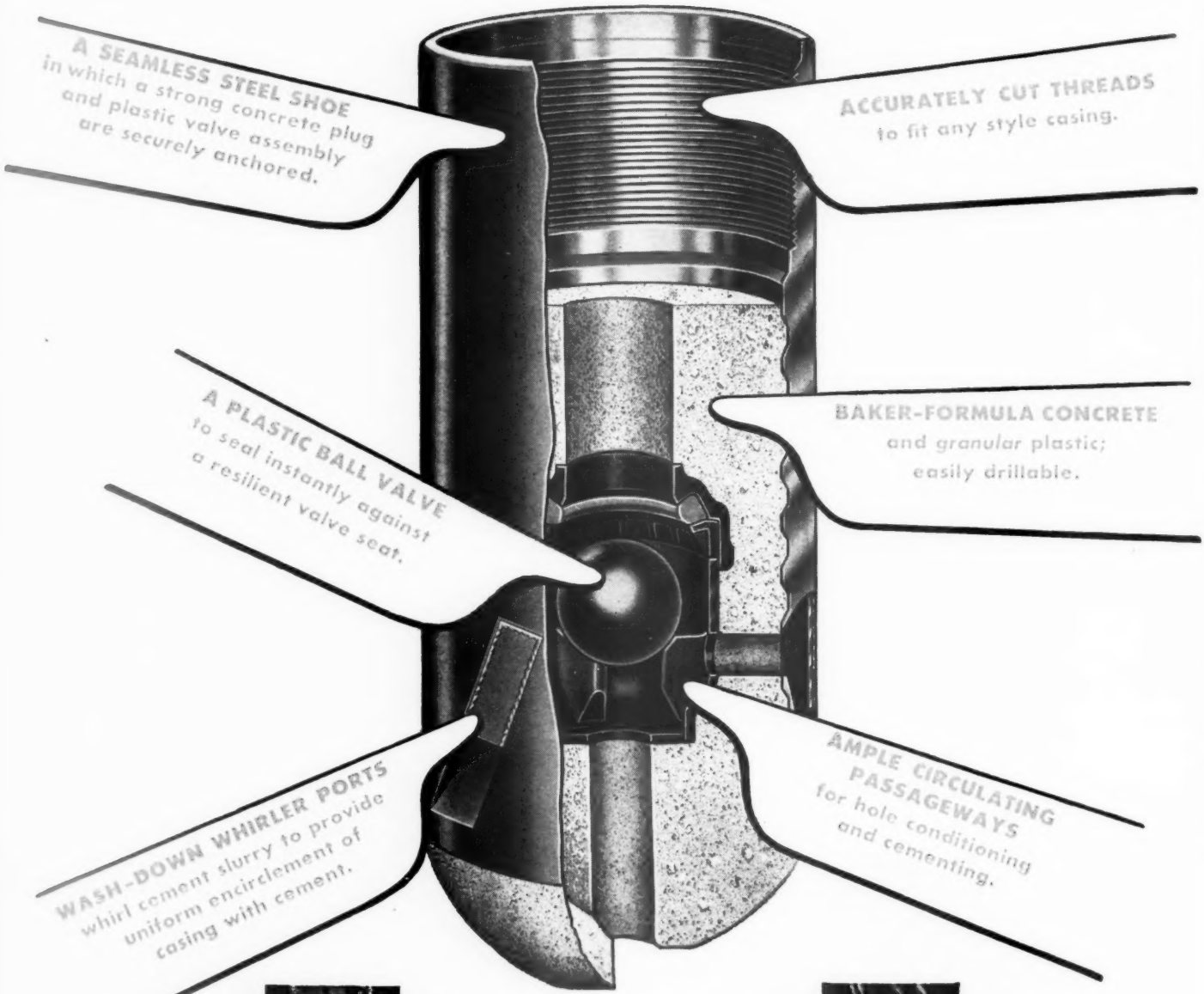
ASK YOUR DISTRIBUTOR

Consult your valve specialist, the friendly near-by Lunkenheimer Distributor. He has a stock of "King-Clip" Valves as well as other fine Lunkenheimer products. Ask for Bulletin 561 which details the 21 standard types of "King-Clip" Valves.

FOR CEMENTING SUCCESS

Use the BAKER Cement Wash-Down WHIRLER Float Shoe

(Product No. 120)


A SEAMLESS STEEL SHOE in which a strong concrete plug and plastic valve assembly are securely anchored.
ACCURATELY CUT THREADS to fit any style casing.
A PLASTIC BALL VALVE to seal instantly against a resilient valve seat.
BAKER-FORMULA CONCRETE and granular plastic; easily drillable.
WASH-DOWN WHIRLER PORTS whirl cement slurry to provide uniform encirclement of casing with cement.
AMPLE CIRCULATING PASSAGEWAYS for hole conditioning and cementing.

· Whirling action reduces hazards of channeling.

Whirling action, plus jetting action, removes bridges and conditions the hole.

YOU WILL FIND *ALL* THESE FEATURES *ONLY* IN THE

BAKER

CEMENT WASH-DOWN WHIRLER FLOAT SHOE

(Product No. 120)

CRUDE, CRACKED AND VOLATILE

An Irishman, who was coming out of the ether in the ward after an operation, exclaimed: "Thank God! That's over!"

"Don't be too sure," said the man in the next bed. "They left a sponge in me and had to cut me open again."

Just then the surgeon who had performed the operation stuck his head in the door and called out: "Has anybody seen my hat?"

The Irishman fainted.

* * *

Indicative of the times is the answer sent by one skillful entrant in a newspaper contest. On the subject, "What I Want in My Post War House," he sent in one well-chosen word, "Me!"

* * *

"What's worse than being a bachelor?"

"Being a bachelor's son."

* * *

The elderly lady, unused to the way of pay phones, was having a battle with the instrument and was asking numerous useless and unnecessary questions of the operator.

Finally, when she was through, she spoke to the operator: "You have been very nice in answering my questions. I am going to put an extra nickel in the box for you!"

* * *

The scene was in the reading room of a large public library. A man was reading birth and death statistics. Suddenly he turned to the man on his right and said, "Do you know that every time I breathe a man dies?"

"Very interesting," replied the stranger. "Why don't you chew gum?"

* * *

When the Indians were running this country, there were no taxes, no debts, and the women did all the work. White men thought they could improve the system.

* * *

Two ardent disciples of Izaak Walton went fishing. After a while one said to the other: "Had any luck?"

"No," was the reply. "I can't get the cork out."

* * *

He: My boss said I was a young man who would go far.

She: You're going just so far—no matter what your boss said.

* * *

There is usually only one reason why a man buys, but with a woman it might be one of eight (so they say): (1) because her husband says she can't have it; (2) it will make her look thin; (3) it comes from Paris; (4) her neighbors can't afford it; (5) nobody has one; (6) everybody has one; (7) it's different; (8) because.

The nurse beckoned to one of a group of expectant fathers who were nervously waiting outside the delivery room. "You are the father of a fine eight pound son," she said.

Another man rushed up to her, and said impatiently, "What's the idea? I was here before he was."

* * *

A group of grade school children were asked the following question by their teacher: "If two automobiles were approaching from different angles, one traveling at forty miles an hour and the other at sixty miles an hour, how old am I?"

After several minutes of meditation one small boy held up his hand and gave his answer as forty-two.

"How did you arrive at this answer?" asked the teacher.

"Well," said the small boy, "my brother is twenty-one and you are twice as crazy as he is."

* * *

A group of sailors on a freighter were frequently entertained by one of their number, a sleight-of-hand performer of no mean ability, during the long evenings at sea. His act, in which cards, money and handkerchiefs were made to disappear, was enjoyed by all aboard—except one—a parrot which greeted each performance with a raucous "Ha, ha, ha! Phooey!"

The ninth night out, in the midst of the show, a terrific storm arose and the boat sank. The prestidigitator was thrown into the ocean and managed to grasp some wreckage to support his weight.

The following morning he was startled to see his critic, the parrot, sitting on an upright on his improvised raft. Not a word passed between the castaways for two days. Suddenly, however, the parrot looked down, cocked his head to one side, and with a gleam in his eye demanded:

"All right, what'd you do with the ship?"

* * *

"Tell me what you eat, and I'll tell you what you are," said a lunch counter philosopher. Whereupon a meek little man, sitting a few stools away, called to the waitress: "Cancel my order for shrimp salad, please."

* * *

An office manager was telling how a girl came in to apply for a job. When asked if she had any particular qualifications or unusual talents, she said she had won several prizes in crossword puzzles and slogan-writing contests.

"Sounds good," the manager told her, "but we want somebody who will be smart during office hours."

"Oh," said the girl, "this was during office hours."

* * *

Arriving at a party on a hot afternoon, he called for something tall, cool and with lots of gin in it.

Just then his host walked up. "May I present my wife!"

* * *

Father to friend: Boy, am I worried! A month ago my wife had triplets, today I come home and she tells me we have twins.

Friend: It's impossible to have twins within a month after you had triplets.

Father: No it isn't—one of the triplets got lost.

---ALL HE SAYS IS THAT LANE-WELLS WILL GET THE JOB DONE RIGHT!
LANE WELLS
GUN PERFORATOR
THE ELMER Q. DEWLAP WELL No. 1
NOW DRILLING

WITH PATTERSON-BALLAGH PLASTIC TUBING PROTECTORS

Prevent tubing collar wear against casing to get more profit from pumping. These Plastic Protectors are oil-proof and wear-resistant—securely bonded at the factory to standard collars in all sizes. They will make your collars and casing wear longer. Check Composite Catalog for details and end your tubing troubles today.

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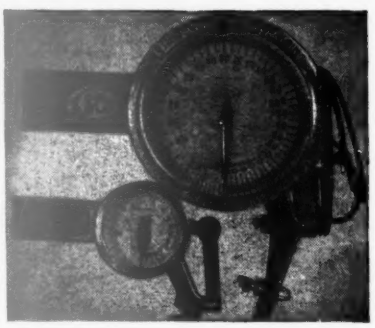
LINE SCALES



(Above) Super 500,000-lb. capacity, 14" dial. (Below) Packer Special, Capacity 40,000 lbs., 6" dial. 18 other models for every drilling, well servicing, or work-over need.

20 MODELS to choose from

With a LINE SCALE you know the pull on the line, and the weight on the bit in pounds. Repeated tests prove the accuracy and dependability of LINE SCALE readings under all working conditions . . . even in areas of rapid temperature changes.

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Supply firm meets

Ken W. Davis, president and general manager of Mid-Continent Supply Company, designated more than 200 division, district, and store managers, salesmen, and technical men from nine states to attend the company's second annual postwar sales meeting, held at the Blackstone Hotel in Fort Worth, Texas, company headquarters, January 24 through 26. The meeting was larger by more than 90 members than last year's session.

Frank John, assistant to the president, presided at the meeting, which was dedicated to the company's expansion to a worldwide organization and a bigger year in 1948. The program consisted for the first two days of talks on the sales program for 1948, general sales activities in all areas, technical equipment distributed by the company, technicolor movies on some of the products, and discussions on all subjects.

A display of new mechanical equipment, including the new Mid-Continent Cummins multiple engine rig drive, was featured at Mid-Continent's Fort Worth diesel shops. On the third day, more than 50 technical men were instructed on Cummins diesel engines, Sheppard diesel engines, Fawick Airflex clutches, and the new Evans thermo-controlled fan.

Davis entertained the entire group with a cocktail hour and buffet dinner at the Fort Worth Club on the first evening.

New officers elected

Due to the expanding operations of The Louis Allis Company, E. P. Allis, president, announces the creation of three new offices. Elected to these new offices were Louis Allis, Jr., vice president in charge of sales; Frank O. Kovich, vice president in charge of manufacturing, and T. R. Wiesemann, vice president in charge of engineering.

In addition to the above elections, Allis appointed C. G. Skidmore sales manager, James H. Daganhardt chief engineer, and John J. Kirkish chief of electrical design.

The Louis Allis Company is completing and moving into a large new factory building and office erected this year.

Hoffman store manager

Appointment of C. Byron Hoffman as manager of the Grandville, Michigan, store of Oil Well Supply Company has been announced by R. R. McAfee, manager of this U. S. Steel subsidiary's eastern division.

Hoffman joined "Oilwell" in November, 1935. He served as store man and later manager of the Muskegon, Michigan, store and for four years was field auditor with the accounting department, working out of Dallas where the company's headquarters are located.

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ALWAYS CHOOSE AFFILIATED NATIONAL HOTELS

Friendly EFFICIENT SERVICE

IN THESE CONVENIENT CITIES

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Hotel Lamar Meridian

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OKLAHOMA
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Hotel Buccaneer Galveston
Hotel Galvez Galveston
Hotel Jean Lafitte Galveston
Coronado Courts Galveston
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Miramar Court Galveston
Hotel Cavalier Galveston
Hotel Plaza Laredo
Hotel Lubbock Lubbock
Hotel Falls Marlin
Hotel Cactus San Angelo
Hotel Menger San Antonio
Angeles Courts San Antonio

VIRGINIA
Hotel Mountain Lake Mountain Lake

Executive Offices Galveston Texas

HOTELS

New API chapter

The Golden Trend chapter of the API at Pauls Valley, Oklahoma, completed its organization with approval of bylaws and constitution and election of officers at a meeting held at Lindsay, Oklahoma, January 14.

Speakers on the program were State Senator J. C. Nance, president protempore of the Oklahoma State Senate, from Purcell, Oklahoma; State Senator Homer Paul, chairman of the Senate Oil and Gas Committee, from Pauls Valley, Oklahoma; Dr. J. J. Mullane, engineer with Carter Oil Company at Tulsa. Oklahoma; and H. M. Stalcup, executive vice president of Skelly Oil Company, Tulsa.

Officers of the Golden Trend chapter of API: Paul Myers, secretary-treasurer; A. K. (Kelley) Hood, first vice chairman; W. E. Best, chairman; Clift Wise, third vice chairman, Ned E. Biffle, second vice chairman. Two officers not in the picture are James Wise, fifth vice chairman and Guy Barrett, fourth vice chairman.

W. E. Best, district petroleum engineer for The Ohio Oil Company at Pauls Valley, was elected chairman. A. K. Hood was elected first vice chairman, Ned E. Biffle second vice chairman, Clift Wise third vice chairman, Guy Barrett fourth vice chairman, and James Wise fifth vice chairman.

Hercules distributor

Lightbourn Equipment Company, 511 South Industrial Boulevard, Dallas, Texas, has been appointed a distributor for Hercules Motors Corporation, Canton, Ohio. A stock of Hercules power units, engines, and repair parts is available for immediate delivery from the warehouse, it is announced.

W. S. Lightbourn

W. S. Lightbourn is the owner of Lightbourn Equipment Company, formerly in the Santa Fe Building since the company was formed in 1945. The move to the new offices and warehouse provides an additional 1800 sq ft of space. Lightbourn has been engaged in the oilfield and industrial machinery business since 1934. A graduate of Georgia Tech in mechanical engineering he was previously employed by the Waukesha Sales and Service Company and at the time of his resignation to form his own company was vice president and sales manager for Texas and Louisiana.

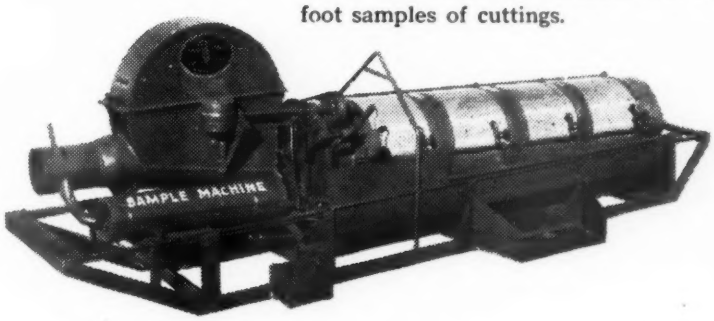
R. F. Park, also formerly associated with the same company as district sales manager, is an associate in the Lightbourn Equipment Company. R. W. Whitman, LSU graduate and a veteran, is in charge of the warehouse.

In addition to Hercules products the company specializes in power plants, pumps, air compressors, V-belt drives, Wilson Manufacturing Company well servicing and drilling equipment, and a complete line of engineering service.

"KILLER" SHALE SAYS:

WHY DIDN'T SOMEONE TELL ME THEY HAD A THOMPSON SHALE SEPARATOR ON THIS WELL?

Shale and abrasives are given the bum's rush when drilling mud goes through a Thompson Shale Separator. Only clean mud, with nothing to chew up expensive drilling equipment, goes back into the well. And there's a Thompson model for any volume of mud flow! The biggest mud pump now in operation can't pump too fast for a Thompson "DWF"—the largest of the Thompson models. *Low cost to buy... no cost to operate!* Attached SAMPLE MACHINE adds to profits by providing accurate foot-by-foot samples of cuttings.



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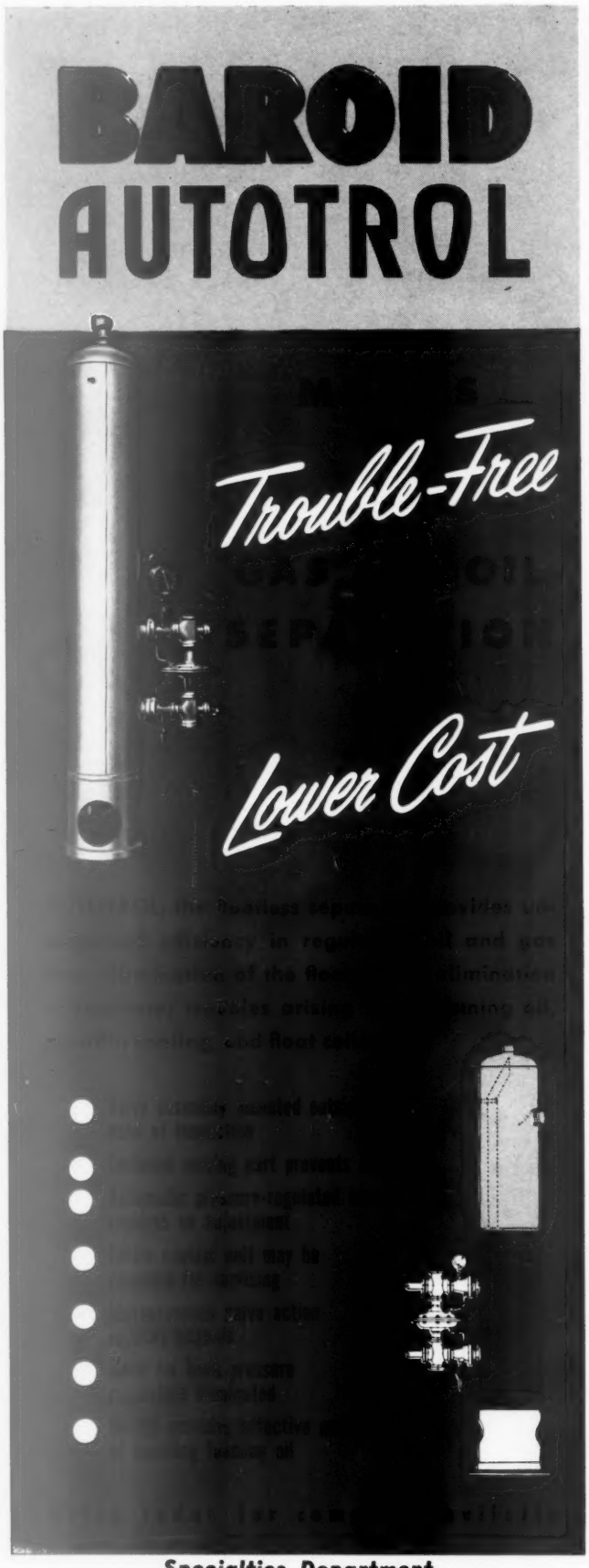
THOMPSON TOOL CO.

IOWA PARK, TEXAS

KEEPS DRILLING MUD CLEAN — PROVIDES *TRUE SAMPLES* OF CUTTINGS



Specialties Department

BAROID SALES DIVISION

NATIONAL LEAD COMPANY

CITY NATIONAL BANK BUILDING, HOUSTON 2, TEXAS

Petrolic Personalities

By DICK SNEDDON

We took a wander down to General Petroleum Corporation's production office at Vernon a short time ago for the specific purpose of saying hello to Hal Marsh and enquiring briefly into the state of his health and general welfare, but to our temporary dismay we found that he wasn't in. The word "temporary" is used advisedly, because our dismay didn't last any longer than a ladyfinger at a bridge tea. It was dispelled completely and eternally by a bit of sunshine from Kansas City, known as Frances Williams. This little lady, with the drab title of receptionist, has more than a personality, she has a veritable luminescence—plus a healthy complement of intelligence, and in a remarkable way complies with the biblical admonition to "brighten the corner where you are." As a matter of fact, we stayed so late, ostensibly discussing the situation in China, but actually studying the much more pleasing immediate situation, that eventually the night janitor came in, took a casual look at our Chippendale legs, and promptly went over us with an O-Cedar mop. Since then, our mind has been in a ferment trying to whip up more reaons for going down to visit Hal Marsh when he isn't in.

●

Diverging atrociously here, our Mid-Continent eye has been roving over the Benedum field in Upton County and scouring such busy West Texas metrollopses as Midland and Odessa, in a mad effort to dig up exclusive items for the readers of this column, both of whom we might say have been very faithful. He reports, our Mid-Continent eye, that is, that the entire area is booming louder than a trench mortar, and that hotels, auto courts, office buildings, and other incipient hostelries are simply bulging with hopeful transients. He declares that he found one sizable family living in a hollow log, and that the incoming arteries are literally jelled with trucks, trailers, trains, burros, and dog sleds, hauling in building materials, Mail Pouch chewing tobacco, and other indispensables to the new camp sites and well locations. Everything, in fact, is coming in but the one thing most needed—pipe. According to our best advices, Iron Drilling Company did a right smart job on the drilling of Alford No. 1, and Jim Hewgley, the production supervisor, is being congratulated on his admirable handling of some ticklish subsurface conditions that under less expert supervision might easily have wrecked the 12,022-ft hole.

Making an on-the-spot survey of the oil properties of Texas for 1948 just recently were Glenn Ruby, Duke Curtice, and James Tully, much traveled members of the firm of Hoover, Curtice and Ruby. They stopped long enough in Fort Worth to pay their respects to Ralph Cummins, Walter Berger, and Charles Pishney, and later supped at the Fort Worth Club with Ken Sclater and Marsh Fagin. The local boys were interested and amused to find Glenn Ruby sporting the new look. Last time he appeared in the public print it was in a scene from Point Barrow, Alaska, and close examination of that photograph indicated that he was about to go down for the last time in an unfathomable sea of whiskers. The hirsute was so profuse that many people thought he was wearing a parka even when he didn't have one on. It poured in a very abandon of ecstasy from his ears and flowed up over his shirt collar. Indeed, it looked as if he had sprouted enough to make a nice comfortable pillow for Bart Gillespie. And, who knows, maybe that is just what happened, for on this present excursion his face was entirely naked. We have been told that he removed the alfalfa voluntarily because he thought that in the oil fields it would constitute a distinct fire hazard.

●

Another late visitor from the frozen tundra to the balmy Mid-Continent was Ralph Coleman, chief engineer for Arctic Contractors. Ralph obviously enjoyed the refreshing climate of Texas, and was particularly partial to the alternate rain and sunshine, after the eternal darkness and persistent blizzardry (if we may coin a word) of the Alaskan winter. But then, of

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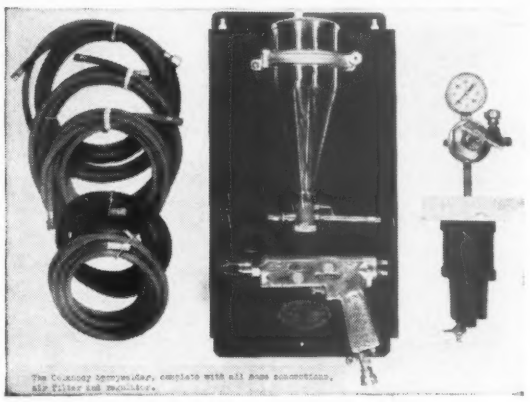

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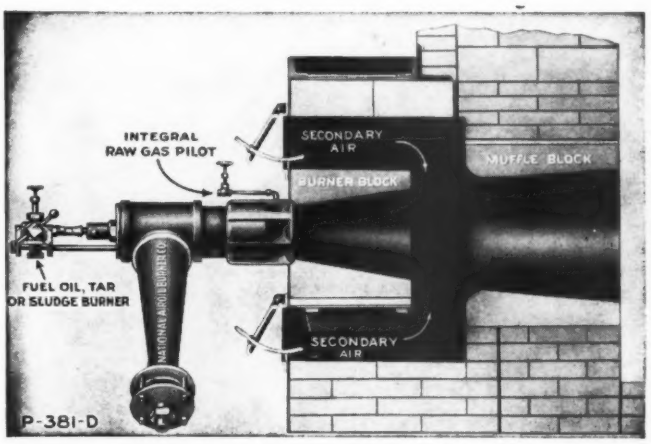

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course, Ralph was in a humor to enjoy almost anything, for, you see, he was on his honeymoon, and we have never yet met a honeymooning man who wasn't easy to get along with—excepting the Scot who went by himself to cut down expenses. The new Mrs. Coleman, incidentally, is an accomplished graduate nurse, and supervised the government hospital for Eskimos at Point Barrow. We might further mention that Ralph is a graduate of University of Texas petroleum engineering department, which is headed by Harry Power, another traveler beside whom Gulliver was an old stay at home. Much as they like Texas and Texans, the Colemans are going back to the land of the midnight sun, where you don't have to pay two bits a cake for ice, and mosquitoes are equipped with pontoons.

●

One of the big excitements in California during February was the opening of International Cementers fine new office building at Long Beach—one of the West's most modern structures. This occasion was rendered specially enjoyable by the generous spread of comestibles that was placed within easy reach and the nice selection of potables that were provided to keep the cosmestibles sufficiently moist for easy digestion. Anent the fine character of the vittles and viands, we can think of no better recommendation than the fact that three times in succession Elmer Decker came all the way back from his home to launch fresh attacks on the buffet. It was a grand time, for which we are indebted to John Chesnut, the unassuming gentleman whose inspiring leadership has done a great deal to bring International to its present status. We enjoyed saying a word of greeting to Jack Smith who travels so much in South America and other foreign parts that you don't often get a chance to say hello to him here. And Frank Smith, the behemoth of swat who can sit a golf ball on a tee and with a driver carve a moat around it as pretty as you please. Then there was George McLaren, the man responsible for the design and construction of the new quarters, a native of Scotland, where if he had done such a neat job as he did at Long Beach, they would almost certainly have given him *two* hearty cheers. Other Cementers with whom we shot the breeze were Holly Hollywood, who, true to his name, has just finished a couple of motion pictures. Photography is Holly's hobby, which explains why he usually clicks with people. We had a few pleasant minutes with Mac Carlisle, the engineering lad who has been hunting for years for a chance to go hunting. He especially likes deer hunting but the nearest he has come to that is to attend an occasional stag party. Last but not least of the I.C. boys with whom we consorted was Orie Dale, with whose writings the readers of *The Petroleum Engineer* are familiar. Orie took us out to see the bulk cementing truck that is discharged by air instead of machinery, and it was interesting all right, but we became so thirsty looking at it we soon had to go inside again. The house warming started at four in the afternoon and broke up after Elmer Decker had his third helping. Among the other visitors to this gala affair, we noted Roy Curl, Ted Sutter, Johnny Merritt, Bill Brooks, John Sherborne, Alex Fraser, Milt Varner, Ray Zell, Russ Hudson, Mac McGee, and so many others it is perhaps foolish to mention any. Nonetheless, we had a good time, and our best wishes go to International Cementers as they stride on into the future with their new headquarters.

●

It is reported that Ed Warren has not relaxed one iota since he turned the controls over to Ned Brown and figuratively stepped off the derrick floor of the AAODC. He is one of these people who just can't be idle and for the past while he has been busier than a candidate for Congress, preparing a talk on drilling contractors' problems, for the North Texas Oil and Gas Association meeting at Wichita Falls. As ex-prexy of AAODC, and vice president of Carl B. King Drilling Company, Ed has been actively interested in promoting research on drill pipe corrosion and fatigue considerations in the deep wells of West Texas. Not meaning to cast any asparagus on his efforts, for Ed is a clear thinker and a lucid and convincing speaker, we are nevertheless reminded of the efficiency expert who was engaged at a fancy salary to determine the cause of fatigue among oil workers. Imagine his surprise when he found that the cause of fatigue among oil workers was efficiency experts.

●

A Midlandite who has been getting around quite some these days is Dick Gile, president of Rotary Engineering Company.

He is not long back from a trip to Caracas, Bogota, and other interesting points in Venezuela and Colombia, where his company has several rotary well logging units in operation. He and Hugh Prather, his associate, have been working into the morning hours to outfit a new unit for Mexico, and expand their core analysis laboratory so as to determine vug and fissure porosities in more of the diamond cores that are being recovered in the new deep fields of West Texas. It is amazing how the vocabulary of the industry grows. We remember the day when a petroleum engineer wouldn't have recognized a vug if it had been served to him for breakfast, and permeabilities, porosities, and bottom hole pressures were so abstruse that nobody but a Ph.D. dared to talk about them. Now, youngsters barely out of high school bandy about with easy familiarity such dainties as dynes, poises, and millidarcys, and any petroleum engineer who isn't on speaking terms with a vug is a —well, a cavity in the social structure.

●

Returning again to the west end of the domestic campus, we learn from our Operative 42 that Ox Morgan, the B-J man about town, is now the proud owner of a nice new television set, valued at a mere $900, which he won in some kind of contest at the Jonathan Club. Pretty lucky we would say. The only thing we ever won was a book called "The Flamingo Feather." That was when at the age of sixteen we won a hundred yard dash for boys under ten. Also figuring in the sports news lately is Ike Messenger, one of Union's landsperts, and a high class golfer. Ike toured the Harding Course at Griffith Park in 66, and we don't mean the year '66. Ike could really have been a pro if some meanie hadn't lured him into the oil business. Had a nice chat in Los Angeles a short time ago with Price Duffield of the Dominican Seaboard Company at Ciudad. He is general manager of operations down there and with his wife was on his first visit to the U. S. in four years. Price is quite a sportsman, too—likes to fish, hunt, golf, and play the ponies. He tells us they have a beautiful golf course in Ciudad, which he is gradually moving several hundred yards to the west—a divot at a time. They have horse races every Sunday, which gives the boys a good opportunity to get nothing for something. His big rave, however, is the Jarauga Hotel—it has no equal he claims in all the West Indies and South America. Rates are $6.00 up—and for oil men with no baggage, $6.00 down. A note from the Ted Lyntons announcing that they are traipsing around Europe preparatory to taking off for the good old U.S.A. They were going up to Stockholm, thence to Oslo and Copenhagen, where they expected to spend a few days with Al Gregersen, then to London, and home! Would guess from the tone of the letter that they kind of hate to leave—the French folk have been mighty good to them—but the prospect of again patronizing the old haunts around Los Angeles has a pretty nice flavor, too.

●

In the last minute roundup, we note that John Gates, ex-Tropical Oiler, is now settled down for keeps, he hopes, in Arcadia, California, right next to Santa Anita race track. Ned Brantly, the Drillex potentate and authority on drilling methods is back from a trip to Brazil. Ott Hammer, Security Engineering chief, is home again after a jaunt to Calgary, Alberta, and wayside points in the Canadian Rockies. Gerard Godet is at University of California, taking a course in petroleum engineering under Professor Uren. Met him in company with M. O. Johnston recently. He was planning on a junket into Texas and will probably be there about the time this goes to press. John Burtt, Shell geological whiz, has a son who is a hotshot reporter on the *Glendale News Press*. George Prussing, one of California's leading safety engineers, and technical secretary of Western Oil and Gas Association, is recently returned from New York. The Reese Taylors were seen steaming into the East a few days ago, and will probably wind up in New York. Which, as old Mr. Euclid used to say is *quod erat demonstrandum*, and we sure wish we knew what he meant.

Kobe promotes J. C. Cooper

J. C. Cooper was recently promoted to district manager for Kobe, Inc., in the Rocky Mountain district, where he has acted as district representative in sole charge of operations since July, 1946. Cooper attended Texas Tech for one year, and the Texas University for two years, majoring in petroleum engineering. From 1936 to August, 1942, he gained considerable

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experience with oil companies in Oklahoma and Texas. In August, 1942, he went to Pearl Harbor, where he worked in construction for the United States Navy until August of 1945, when he returned to the States. He joined Kobe in September, 1945, as a junior engineer attached to the California division technical service. March, 1946, he was assigned to district operations in the Valley District of California, where his accomplishments earned him the appointment of district representative in the Rocky Mountain district in Colorado in July, 1946.

Dowell opens New Orleans district

Dowell Incorporated, through its general sales manager, R. D. Shaw, announces the formal opening of its New Orleans district. This district includes south Louisiana, all of Mississippi, Alabama, and western Florida and is the headquarters for all of the company's operations, both oil field and industrial divisions, in this area.

L. B. Swan

L. B. Swan has been appointed manager of the new district and is now residing in New Orleans. Swan has been with Dowell Incorporated since 1940 during which time he has had experience in all oil producing areas of the United States. For the last four years he has been at the company's general office in Tulsa, serving as development engineer for the oil field division.

The district office is in New Orleans with R. L. Dickson as office manager. The new district includes the Dowell station at Lafayette, Louisiana, with C. L. Power, Jr., as development engineer and J. O. Hendrick as station manager; the station at Hattiesburg, Mississippi, with Z. V. Morgan as station manager; the Baton Rouge, Louisiana, industrial area with L. G. Hargett as development engineer. The plans now include a future station at Houma, Louisiana.

Cooper elected president

Harold E. Cooper, a vice president and director of Fred E. Cooper, Inc., Tulsa, Oklahoma, has been elected president of this well-servicing equipment and power engine unit manufacturing company. He succeeds his uncle Fred E. Cooper, who died in an airplane accident on February 6.

H. E. Cooper

The board of directors of the corporation elected J. W. Allen to the board and as vice president of the corporation. Allen has been associated with the organization since 1928. He will continue to be manager of manufacturing.

Howard B. Appleton was made secretary-treasurer formerly having been secretary. H. B. Bloxom, whose appointment has been previously announced, is sales manager of the company.

The general offices and manufacturing plant of Fred E. Cooper, Inc., are in Tulsa, Oklahoma. Branch plants are maintained in Houston, Texas, and Los Angeles, and Lynnwood, California.

Major G-E appointments

Four major appointments in the control divisions of the General Electric Company's apparatus department have been announced by K. R. Van Tassel, manager of the divisions. Van Tassel named M. H. Blesh, manager of manufacturing, C. B. Bradish, manager of engineering, and E. A. Green, manager of sales. Simultaneously, Guy S. Hyatt, apparatus department comptroller, announced the appointment of Thomas I. Hage as accountant for the divisions.

The control divisions, one of the new "businesses" recently established by the apparatus department, has the largest employment of any of the company's Schenectady divisions. Approximately 650 persons are employed by the divisions' activities in the works and general offices. The organization is responsible for the engineering, manufacture, and sale of control devices and equipment for apparatus used in the industrial and aircraft fields, and in domestic appliances.

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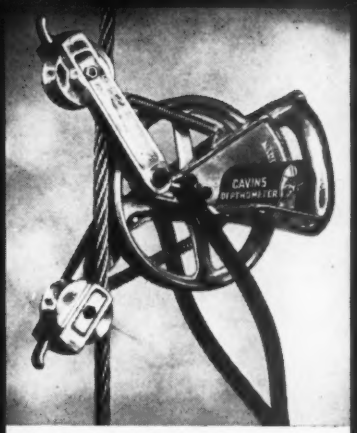

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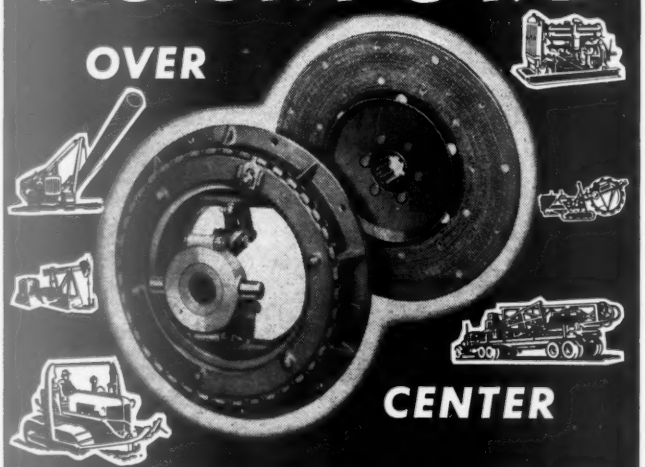

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Los Angeles Nomads officers

Los Angeles Chapter Nomads officers, posed at the Annual Inaugural Ball at the Biltmore Hotel, February 14. Left to right, standing: B. M. Landis, secretary; John Rife, executive secretary; Fred Ripley, Jr., president; Jerry Engstrand, deputy sergeant-at-arms; Lee Laird, vice president; kneeling, R. J. Eiche, past president; Earl Boggess, sergeant-at-arms, and John Flanagan, assistant treasurer.

Mid-Continent Supply promotes

Ken W. Davis, president and general manager of Mid-Continent Supply Company, worldwide oil field supply distributors with headquarters in Fort Worth, Texas, announced the following transfers and promotions at the company's recent annual sales meeting, held January 24 through 26.

D. S. Smith, former district manager at Wichita Falls, Texas, has been transferred to head the Dallas district, recently changed to include Dallas, Kilgore, and East Texas. N. W. Dail, former store manager at Rangely, Colorado, has taken his place at Wichita Falls. The position at Rangely has been filled by M. C. Shaw, formerly at Kilgore.

W. H. Loyd, Jr., former store manager at Refugio, has been promoted to assistant district manager of the San Antonio district, in charge of Refugio and Falfurrias, Texas. W. W. Schmid of Refugio was named store manager there.

H. B. McCullough has been raised from field salesman at Kilgore to store manager. R. B. King has been transferred from Kilgore to Shreveport as city salesman.

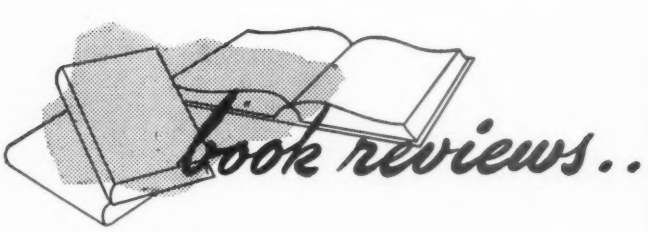
Heuser assistant sales manager

The appointment of John E. Heuser as assistant sales manager of the Le Roi Company has been announced by John M. Dolan, vice president in charge of sales for the Milwaukee company. Heuser will take over many of the duties of Cecil W. Brown, who recently resigned as general sales manager of the company.

Market development division

A market development division has been created as a new unit of the sales department of United States Steel Corporation of Delaware, it was announced by David F. Austin, vice president—sales. The new division began functioning March 1.

R. J. Ritchey, now manager of market development of Carnegie-Illinois Steel Corporation, United States Steel subsidiary, has been appointed director of the new division of the Delaware Corporation, Austin also announced.



● **Natural Gasoline and the Volatile Hydrocarbons,** *Section I, by G. G. Brown, D. L. Katz, G. G. Oberfell, and R. C. Alden. Natural Gasoline Association of America, 422 Kennedy Building, Tulsa, Oklahoma. Price, $4. Pages, 96.*

Sixty-eight charts and twenty-five tables illustrate this long-needed text on natural gasoline operations. The properties of the volatile hydrocarbons and their application to natural gasoline extraction processes and cycling operations will aid the engineer. Essential data for calculations and the voluminous bibliography are gathered in convenient usable form. Illustrations of the use of data and solutions of hypothetical problems clarify many of the complex problems of hydrocarbon behavior. Detailed methods for applying fundamental information in specific calculations give this book wide appeal to anyone interested in the behavior and processing of hydrocarbons.

● **1948 Directory of Pipe Line Personnel,** *published by The Midwest Oil Register, P. O. Box 892, Tulsa, Oklahoma. Price, $10. Pages, 134.*

A new pocket-size directory published by C. L. Cooper brings a complete revised listing of Midwest pipe line personnel. Forty-five hundred individual names, including crude oil, natural gas, and products personnel, are given. A special section is devoted to pipe line contractors of this region. The miles of pipe line by sizes and the number of pumping stations owned by each company are presented. Men of the industry will find this directory useful on many occasions, as will sales engineers, managers, and advertising men.

● **Compressed Air Handbook,** *by Compressed Air and Gas Institute, 90 West Street, New York 6. Price, $3 in United States; $3.50 elsewhere. Pages, 387.*

Compiled and edited by the Educational and Technical Committees of the Institute, this handbook reveals the vast scope of applications for compressed air.

In the oil industry alone, compressed air is used from drilling operations through the last refinery run. In the field, compressors are used to pressurize wells, to pump oil and gas to the surface, and to cement. In refineries, air agitates and transfers acids, displaces and transfers oil. Pneumatic tools are used in cleaning, caulking, riveting, and other maintenance work on tanks, tubes, and pipe lines.

The final section contains definitions, rating standards, data, tables and formulae and test procedures.

● **Petroleum Facts and Figures,** *by the American Petroleum Institute, Department of Information, 50 West 50th Street, New York 20. Price, $2. Pages, 236.*

This eighth edition of *Petroleum Facts and Figures* contains all the authoritative information about the petroleum industry from 1941 through 1946 that can be reduced to statistical form.

There are seven main divisions in the new volume; utilization, production, refining, transportation, marketing, general information and world statistics. A complete index will aid the reader.

● **Bibliography of the Theory, Apparatus, as well as Procedures of Distillation and Rectification,** *edited by H. Stage and Gg. R. Schultze. Hobart Publishing Company, P. O. Box 4127, Chevy Chase Branch, Washington 15, D. C. Price, $6.75. Pages, 180.*

An original German work, published by the VDI in Berlin in 1944, this bibliography contains a thorough compilation of distillation and rectification literature for the years 1920 to 1944.

References are in German, English, and French, according to their origin. Almost all the material is available in either photostat or microfilm form. Orders may be routed through the publishing company, a service that will enhance this reference book's value.

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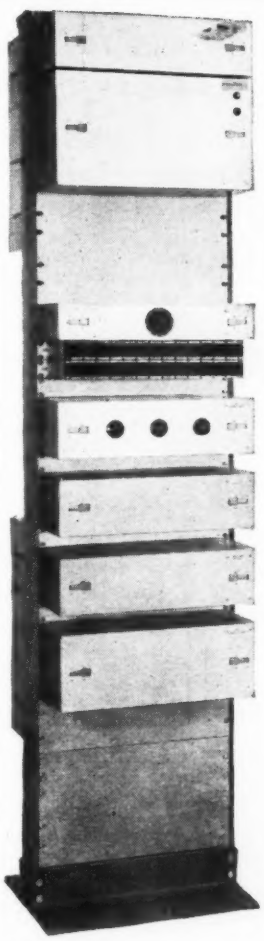

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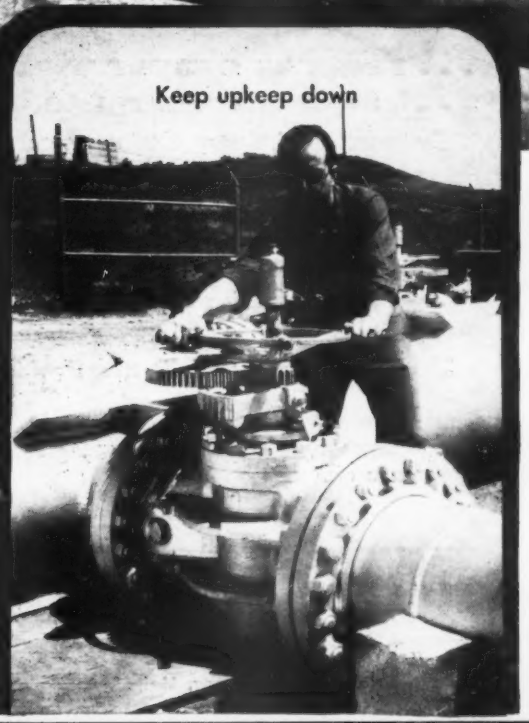

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THE HORTON DOUBLE-DECK FLOATING ROOF

. . . reduces evaporation losses
. . . helps maintain the quality of the product stored

The petroleum industry obtains several important benefits by the use of the Horton Double-Deck Floating Roof. First, this roof eliminates all filling losses and reduces breathing losses that normally occur when a volatile product is stored in a fixed-roof tank. Second, it helps maintain the physical properties of the product stored. In addition, it also reduces fire hazard during the storage period and is one of the best means of eliminating corrosion which normally occurs in a cone-roof tank.

The Horton Double-Deck Floating Roof is used on flat-bottom tanks storing crude oil, gasoline and other petroleum products. It is particularly recommended for working tanks that are filled or emptied several times a year. tanks in blending service and tanks containing sour crude oil.

COMPARE THESE FIGURES

The figures below show how breathing and filling losses compare in an 80,000-bbl. cone-roof tank and an 80,000-bbl. Horton Double-Deck Floating Roof Tank. The calculations are based on a 10-lb. Reid Vapor pressure gasoline at 56°F. The fixed-roof tank averages one-third full.

CONE-ROOF TANK

Annual breathing losses	1700 bbls.
Losses during one filling	120 bbls.

HORTON DOUBLE-DECK FLOATING ROOF TANK

Annual breathing losses	180 bbls.
Losses during one filling	None

(Evaporation losses shown in barrels of 42 U. S. Gallons)

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